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THE EVOLUTION OF MONOCOTYLEDONS.

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(WITH SIX FIGURES)

NO SUBJECT is of more general interest to botanists than the early race-history of angiosperms. In a recent paper[1] I have attempted to justify the publication of a new hypothesis on this subject by a detailed account of the embryological evidence on which it is founded. The details of such work, however, have little interest for any but specialists, and I wish to deal here with the wider aspects of the subject. The argument of the following pages is in substance that contributed to a discussion on the evolution of monocotyledons which was held in September, 1903, at the Southport meeting of the British Association for the Advancement of Science. The whole paper has been recast since then, much has been added, and something omitted; in particular several passages have been introduced in answer to objections raised during the discussion.

There is a remarkable absence of direct geological evidence concerning the origin of angiosperms and the comparative antiquity of the two races included in that group. In the present state of our knowledge all conclusions with regard to the race-history of angiosperms must be founded on the comparative morphology of living forms. On such grounds, however, I have ventured to assume that monocotyledons and dicotyledons will ultimately be traced back to a common ancestor which in all

[1] SARGANT E., A theory of the origin of monocotyledons. Annals of Botany 17:1. 1903.

essential features was an angiosperm, in spite of the fact that several modern authorities hold the contrary opinion.[2]

The isolation of the angiosperms, long recognized, has been emphasized by recent work. On the one hand, the connection of gymnosperms with pteridophytes has been so far traced through forms now extinct that the degree of relationship between those groups can be estimated, while no link has been found to connect the angiosperms with any other group. Thus our ignorance of their genealogy is the more obvious by contrast with increasing knowledge concerning that of other vascular plants. On the other hand, the internal structure of the embryo sac both before and after fertilization has been shown of late to separate angiosperms from other forms even more completely than was formerly supposed.

The gulf which separates angiosperms from all other plants is indeed of unknown depth. By comparison the internal boundary which divides monocotyledons from dicotyledons is very insignificant. The points of resemblance between members of these two classes are far more numerous and more important than those in which they differ.

Translated into the language of evolution, this means that the angiosperms are a race of considerable antiquity, which at some epoch in its history gave rise to two branches, monocotyledons and dicotyledons. If this is the case, it is clearly a point of great importance to obtain some notion of the structure of the primitive angiospermous stock.

Whatever the primitive angiosperm may have been, we may fairly assume that it was not a perfect mean between the monocotyledon and dicotyledon, nor on the other hand totally unlike either. Which did it most resemble? In other words, which type is the more primitive?

This is no new problem. It has been debated for upwards of fifty years, and during that period most botanists have maintained the superior antiquity of monocotyledons. Of late this

[2] BALFOUR, I. B., Presidential address to section K of the British Association. 1901. COULTER, J. M., The phylogeny of angiosperms. Decennial Publ. of University of Chicago. 1903.

opinion has lost ground. The evidence which supports it has been criticised, and more than one observer has brought forward facts in favor of the claim of dicotyledons to be considered the elder branch.

EVIDENCE FOR THE PRIMITIVE MONOCOTYLEDON.

The case for monocotyledons rests on evidence drawn from three distinct lines of research: (1) the direct evidence of fossil botany as to the geological succession of forms; (2) comparison of the stem anatomy in the two classes; (3) the study of the developing embryo within the embryo sac.

1. Direct historical evidence from the succession of fossil forms would of course be more conclusive than any based on comparative morphology. But unfortunately the geological record is particularly imperfect at the epoch which separates the gymnospermous flora of the Mesozoic age from the earliest fossil floras in which angiosperms can be recognized with certainty.[3]

2. The absence of a normal thickening ring in the stem of monocotyledons was formerly considered a primitive character. This was a very natural inference at a time when a normal cambium was unknown except among gymnosperms and dicotyledons. It led to the now discarded classification which united gymnosperms with dicotyledons, of which traces may still be found in systematic text-books.

But now that the anatomy of many fossil cryptogams is as well known as that of any living forms, we realize that cambial thickening was a commonplace in vegetable anatomy long before the advent of angiosperms. Some of the ancestors common to monocotyledons and dicotyledons must almost certainly have possessed it, and if so, its absence from the stem of monocotyledons must be regarded as the loss of a primitive character.

3. The argument from the history of the embryo within the embryo sac is that which has perhaps had the most weight with botanists. The facts are shortly these:

In both classes the cotyledons are commonly the first mem-

[3] SEWARD, A. C., Presidential address to Section K of the British Association. 1903.

bers differentiated from the mass of meristem which constitutes the embryo. Among monocotyledons the single cotyledon forms a club-shaped termination to the axis, and the boundary between these members is first clearly defined by the appearance of a lateral cleft within which is formed the growing-point of the stem. Thus the cotyledon is apparently terminal in monocotyledons, the stem bud lateral (*fig. 3* on p. 340).

In the dicotyledonous embryo a similar enlargement appears at one end, but it is sooner or later divided into two lobes by a median cleft, within which the stem bud is formed. As soon as this takes place the cotyledons appear lateral, the stem bud terminal.

The accepted interpretation of these facts is that the club-shaped enlargement of the dicotyledonous embryo before lobing begins is equivalent to that which gives rise to the single seed leaf of monocotyledons. Its subsequent bifurcation indicates the origin of both cotyledons from that of an ancestor which possessed but one. This interpretation has been recently urged by Mr. Lyon in his paper on Nelumbium.[4] In this species the meristematic mass at the end of the embryo attains some size before it gives rise to a pair of cotyledons. The stem bud first appears in a lateral position with regard to it, and later reaches a symmetrical station between the cotyledons by degrees. The embryo is said by Mr. Lyon to pass through a monocotyledonous stage, and he is even prepared on the strength of these observations to class Nelumbium among monocotyledons. Professor Strasburger[5] has observed with great force that the position of the embryo at one side of the embryo sac of Nelumbium has probably more to do with its one-sided development than any ancestral reminiscence.

A similar criticism may, I think, be applied to the whole argument. A parasitic mass of meristem which is forced to develop within very narrow limits naturally assumes the most convenient form, and any detail of shape is at least as likely to be due to its environment as to inheritance from remote ancestors.

[4] LYON, H. L., Embryogeny of Nelumbo. Minnesota Bot. Studies **2** : 643. 1901.

[5] STRASBURGER, E., Ein Beitrag zur Kenntniss von *Ceratophyllum submersum*. Jahrb. Wiss. Bot. **37** : 477. 1902.

This view is strengthened by what we know of the development of the embryo among pseudo-monocotyledons. Scattered here and there among normal dicotyledons are species, or small groups of species, which on germination show a single seed leaf. There is no doubt whatever as to the affinities of these forms. We can safely assume that at some geologically recent period the common ancestor from which sprang all the species in the genus Corydalis, for instance, must have possessed two distinct cotyledons. Most species of Corydalis still possess two, but *C. cava* and a few allied forms have but one. There can be no doubt here that the species with a single seed leaf are derived from an ancestor with two. It would seem that the early history of the embryo ought to throw light on the way in which this took place. In such a form as *Corydalis cava* we should expect to see the bifurcation begin in the very young embryo, and that the two members thus indicated would later be reduced to one, either by the abortion of one of them or by the union of both.

Hegelmaier[6] described the formation of the embryo in several pseudo-monocotyledons in 1878. He worked out every detail in three species, beginning with the fertilized ovum and ending with the ripe seed. In each case he examined for comparison the embryos of closely allied species in which both cotyledons were present. His work has been completed by that of Sterckx[7] and Schmid,[8] who have traced the development of the embryo in those three species through its long period of maturation within the ripe seed down to the epoch of its germination.

In *Ranunculus Ficaria*, *Corydalis cava*, and *Carum Bulbocastanum* the history of the embryo from fertilization to germination is now complete. In all three species the cotyledon is single from the first. No bifurcation appears at any stage, though the cotyledon of *Ranunculus Ficaria* soon becomes—and remains—slightly two-lobed. The plumule is formed in a deep cleft which marks

[6] HEGELMAIER, F., Vergleich. Unters. über Entwick. dicot. Keime. Stuttgart, 1878.

[7] STERCKX, R., Recherches anat. sur l'embryon et les plantules . . . . des Renonculacées. Mém. Soc. Roy. Sci. Liège III. **2**:—. 1899.

[8] SCHMID, Beitr. zur Embryo-Entwick. einiger Dicotylen. Bot. Zeit. **60**: 207. 1902.

the level dividing the axis of the embryo from its cotyledon. But as the cotyledon develops it does not appear terminal as it commonly does among true monocotyledons. The plumule soon comes to lie in a straight line with the axis, and the cotyledon is a hollowed structure which partly surrounds it. Indeed, the whole embryo at this age closely resembles that of Tamus as described by Solms-Laubach, in which the cotyledon appears lateral from the first (*figs. 4, 5, 6*, p. 340).

Hegelmaier indeed describes a single abnormal embryo of *Carum Bulbocastanum* in which the lower lip of the usually lateral cleft containing the plumule attains some size, and he interprets this structure as the rudiment of a second cotyledon. Little weight can be attached to an isolated case of this kind. We do not even know whether the lump of tissue he figures would have become a leaf-like member. This is the only ground for considering the absence of a second cotyledon in any pseudo-monocotyledon as due to its early abortion. We may therefore fairly say that the comparative study of the young embryo in the genera Ranunculus, Corydalis, and Carum does not indicate the process by which a species within those genera has come to possess a single cotyledon where its ancestor had two.

The history of the embryo within the ovule and seed then throws no light on the comparatively simple problem of the derivation of such forms as *Corydalis cava*, *Ranunculus Ficaria*, or *Carum Bulbocastanum* from the ancestral Corydalis, Ranunculus, or Carum. This consideration casts great doubt on the value of similar evidence when we attempt the harder task of tracing the origin of monocotyledons from an ancestor far more remote.

To sum up, research conducted on the three lines hitherto considered does not afford evidence of any great value in favor of the superior antiquity of monocotyledons. On the other hand, it does not so far support the opposing claims of dicotyledons.

EVIDENCE FOR THE PRIMITIVE DICOTYLEDON.

Two observers, M. Quéva and Professor E. C. Jeffrey, have recently appealed to anatomical evidence of a kind hitherto neglected. M. Quéva has made a careful anatomical study of

several monocotyledons, including the liliaceous climber *Gloriosa superba*.[9] In this species he finds a well-marked cambium within the bundles of the second-year tuber and of all succeeding tubers. Secondary elements are added to the xylem and phloem of each bundle by its cambium, which is active throughout the two seasons during which the tuber lasts. Moreover, the bundles in the climbing stem of the seedling possess a cambium, though the elements which it contributes to the xylem and phloem soon lose their radial arrangement by further growth. M. Quéva comes to the following conclusion: "La persistance de la zone cambiale dans certains faisceaux des Monocotylédonées prouve qu'il est logique de considérer ces plantes comme dérivant de Dicotylédonées inférieures par extinction précoce de la zone cambiale et par augmentation du nombre des faisceaux de la trace foliaire" (*l. c.*, p. 147).

It will be remembered that Miss Anderssohn in 1888 described a cambium in the bundles of the young stem of several monocotyledonous seedlings.[10]

Professor Jeffrey has recently expressed his phylogenetic conclusions without reserve: "In the present state of our knowledge we are apparently justified in considering the monocotyledons to be a modern, strictly monophyletic, and specialized group, derived from dicotyledons or their parent stock, possibly by adaptation in the first instance to an amphibious mode of life."[11]

The evidence on which this view is based is the comparison of the mature stem anatomy with that of the seedling in what may be called the third period of its life. The first includes all the time during which the embryo is completely inclosed by the ovule or seed. The second period begins with germination, and while it lasts the seedling consists mainly of cotyledon, hypocotyl, and primary root. The young stem bud is present, but is

[9] QUÉVA, C., Contributions à l'anatomie des monocotylédonées. Mem. de l'Université de Lille. 1900.

[10] ANDERSSOHN, S., Ueber d. Entwickel. d. primären Gefässbündelstränge d. Monokotylen. Bihang till K. Sv. Vet. Akad. Handl. **12**: 188 (Bot. Centralbl. **38**: —. 1889).

[11] COULTER and CHAMBERLAIN, Morphology of Angiosperms 316. 1903.

small compared with the cotyledon, and is usually more or less protected by it.

In the third period the stem bud becomes the ascending axis, and the cotyledon—even if persistent—is dwarfed by its rapid development. In the early part of its third period the plant is still very far from maturity. The epicotyl of monocotyledons contains at this time a single ring of collateral bundles, which may even show traces of a cambium. The stem, in fact, resembles that of a dicotyledon. In some monocotyledons the mature rhizome and the nodal regions of the aerial stem are characterized by amphivasal bundles. These are not found in the seedling (Jeffrey, *l. c.*).

There is nothing forced about the explanation of these facts given by Professor Jeffrey. As the characters of the young stem recall those of a dicotyledon, the features of monocotyledons appearing later in life, it is to be concluded that the stem anatomy of the common ancestor was essentially dicotyledonous. As has been said already, the anatomy of fossil cryptogams establishes a presumption that the primitive angiosperm possessed secondary thickening. The traces of the process found in the immature stem of monocotyledons strongly confirms this presumption.

For some years I have been employed on a comparative examination of monocotyledons soon after germination—as a rule during what I have called their second period of growth. About this epoch the vascular system of the immature structure is first completely defined by the lignification of the xylem.

This work has led me to the conclusion that monocotyledons are descended from an ancestor with two cotyledons, and that the single cotyledon which distinguishes them is a member formed by the fusion of the pair. For the nature and strength of the evidence I must refer to a previous paper.[12] It is sufficient to say here that the absence of a true midrib is a very general character in the cotyledon of monocotyledons, that its place is commonly supplied by two equivalent bundles, and that in the

[12] SARGANT, E., A theory of the origin of monocotyledons. Annals of Botany 17 : 1. 1903.

more primitive forms these bundles are massive and very widely separated.[13] The suggestion that each represented the midrib of an ancestral cotyledon seemed an adequate and simple explanation of the phenomenon, and it was much strengthened when I examined a number of dicotyledons—all from the Ranales—in which the cotyledons are partially united. The simplification of structure caused by this incomplete union was found to reduce the vascular symmetry of the ranal seedling (Eranthis, Podophyllum) to a skeleton much resembling that previously described as primitive among monocotyledons (Anemarrhena, Albuca).

An angiospermous plant possessing two seed leaves and exogenous stem structure would certainly, if now discovered, be ranked among dicotyledons, even though in other characters it should resemble a monocotyledon, or differ from both classes. Assuming an ancestor with these two characters, monocotyledons must be considered as derived from a dicotyledonous stock, not necessarily at one epoch or from a single strain. Can indications be found in the structure of living plants to suggest the conditions which operating for a length of time on such a stock might lead to the formation of a race or races essentially of the monocotyledonous type?

Beginning with the most general character and that which gives its name to the class, we may ask: Under what circumstances is the possession of a single cotyledon in place of two an advantage to the plant? An answer to that question is naturally sought among the few dicotyledons which possess but one seed leaf. I have compiled a list of species with this character.[14]

[13] The forms to which I refer are liliaceous: Anemarrhena, Albuca, and others nearly allied to these very distinct genera both in mature and in seedling characters. I believe them to be primitive among the Liliaceae after making a careful comparative study of seedlings from forty-five genera of that family. Systematists differ as to the position of the Liliaceae among monocotyledons. Some believe the type to be an ancient one from which many simpler monocotyledons are derived by reduction. My observations on the structure of seedling monocotyledons from a number of families incline me to accept this view, and on general grounds I prefer to attribute simplicity of structure when found in such advanced types as the angiosperm to reduction rather than antiquity. Anemarrhena and Albuca, then, if primitive among the Liliaceae are primitive also among monocotyledons in general.

[14] SARGANT, E., *l. c.*, p. 76.

They belong to eight genera which are systematically scattered, for they represent six families, Ranunculaceae, Fumariaceae, Umbelliferae, Primulaceae, Lentibularieae, Nyctagineae. Clearly these species cannot have inherited the peculiar form of their seedling from a common ancestor. It must be due to similar external conditions affecting certain species of very different descent in the same way.

One feature is common to all the pseudo-monocotyledons in my list—they all possess some underground member which is thickened into a tuber. In *Ranunculus Ficaria* one of the earlier cauline roots becomes tuberous; in the other species the hypocotyl is more or less thickened.

Moreover, the most complete list I can make of dicotyledons with their cotyledons partially united for some distance from the base upwards includes twenty genera.[15] It contains but one genus—Rhizophora—in which the hypocotyl is not very much shortened, if not actually thickened. In the great majority the hypocotyl becomes a conspicuous tuber. The seeds of the single exception germinate under peculiar conditions,[16] which would account for almost any amount of modification in the structure of the seedling.

The association of a tuberous habit with the reduction of the cotyledonary members has been noticed by several observers. Darwin in the *Movements of Plants*[17] says: "From the several cases now given, which refer to widely distinct plants, we may infer that there is some close connection between the reduced size of one or both cotyledons and the formation, by the enlargement of the hypocotyl or of the radicle, of a so-called bulb."

Now the formation of a shortened and generally thickened rootstock, whether morphologically a stem or a root, is characteristic of the plants which Professor Areschoug[18] has called geophilous. Such plants are found in regions where the conditions during part of the year are unfavorable to vegetation.

[15] SARGANT, E., *l. c.*, p. 73.

[16] KERNER and OLIVER, Natural History of plants 1:602–4.

[17] DARWIN, C., The power of movement in plants 97. 1880,

[18] ARESCHOUG, Beiträge zur Biologie der geophilen Pflanzen. Lund, 1896.

During the winter of temperate, alpine, or arctic climates, during the prolonged drought of regions with a periodical dry season, such plants lose all their aerial organs and are left with the underground stock only. This is commonly a squat axis with roots and foliage buds—perhaps flower buds also—attached to it. A store of nourishment is always laid up in some part of this subterranean structure, as a rule in the enlarged stem.

The more rigorous the conditions, the more pronounced the adaptations to them. When the growing season is short, the flower of a geophyte often comes up with or before the leaves. No part of the genial weather is then lost with regard to the formation and ripening of the seed. When once ripe, the seed fears neither frost nor drought, but the seedling is less hardy. The great problem before a seedling which germinates under such conditions is how in the course of the short growing season it may best prepare to face the rigor of the coming months. Its first care is to form an underground storehouse in the shape of a swollen stem or root to which the food packed in the seed may be transferred. This store of food is plunged in the soil, at first by the downward growth of the seedling as it leaves the seed coats, and later by the contraction of the root system which drags the tuber lower still.[19]

In some species this is all that the seedling accomplishes in its first season (Arum, Erythronium,[20] Veratrum): it has lived on part of its food capital in order to place the rest in safety. But as a rule one, or even two, green leaves are sent up soon after germination, and then the contents of the storehouse are replenished by the activity of the assimilating surface.

The formation of assimilating organs in the seedling of a geophilous plant is, however, very greatly limited by the shortness of the growing season and the necessary formation of subterranean organs. Here lies the explanation we were seeking; the reduction of the cotyledons and the formation of a tuber are both adaptations to the geophilous habit.

Suppose a race of primitive angiosperms to be specialized as

[19] RIMBACH, Ber. Deutsch. Bot. Gesell. **15**:—. 1897.

[20] IRMISCH, Beitr. z. vergleichenden Morphologie der Pflanzen. Halle. 1854.

geophytes. Their originally distinct cotyledons become more and more closely united in order to economize material. In the end a single cotyledonary member is formed by their complete fusion. A monocotylous race might easily be derived in this way from one with two cotyledons.

But monocotyledons are distinguished from dicotyledons by other characters besides the single seed leaf. Taking these characters one by one, are they consistent with the hypothesis that monocotyledons were derived from a stock of dicotylous angiosperms by adaptation to the geophilous habit?

As has been said (p. 332), there are independent grounds for believing that monocotyledonous stem anatomy is derived from that of an ancestor framed on the dicotyledonous type. Modification of the ancestral stem structure in this direction might well follow on the gradual assumption by succeeding generations of the geophilous habit. For in every plant which passes part of the year underground a large foliage bud is formed on the subterranean stock in the course of a growing season, and this bud after remaining quiescent through the bad weather will push up as the next period of growth approaches. Such buds are formed even in the least specialized geophytes.

Scale leaves form the outer covering of such a bud; then follow the radical leaves which sometimes, but not always, surround the rudiment of an erect stem which will bear flowers as well as leaves. Scale leaves and radical leaves alike are broad-based; the insertion of each on the squat axis occupies a considerable segment of its circumference. When growth begins with the first genial weather, the axis does not elongate, or those basal internodes, at any rate, are suppressed which separate the whorls of scale leaves and of radical leaves from each other. The traces which enter the axis from those leaves fall naturally into concentric circles within it. In fact, they are at once arranged like the leaf traces of a monocotyledonous stem.

In many geophytes the parenchyma of the axis becomes a massive tissue packed with food stuff. This development of the tissue which surrounds them naturally tends to isolate the leaf traces from each other. The interfascicular cambium first dis-

appears, and then the cambial layer within each bundle, for no development of secondary elements is needed.

The structure of some living geophytes illustrates this process. In the first and second year tubers of Eranthis[21] and Arum,[22] for example, we find the slender leaf traces isolated among the abundant parenchymatous tissue which is packed with starch. The Cyclamen tuber is formed in a similar way.

Though this method of tuber formation is quite common, it is not universal. Jost's researches on *Corydalis solida*[23] show the tuber to be formed in this species by the activity of a normal cambium which adds a mass of parenchymatous elements to xylem and phloem alike. The reserve food is stored in the tissue thus produced. Each year sees a fresh tuber formed within that of last year, which it destroys. My own observations on first-year seedlings of *Anemone coronaria* and *Delphinium nudicaule* show that their tubers are formed in a similar way. The tissues—chiefly parenchymatous—which thicken them are added by a normal cambium. I have not examined older seedlings or mature plants.

Podophyllum offers the best example with which I am acquainted of a dicotyledon which, according to the present hypothesis, may be considered as arrested on the way to become a monocotyledon. A full account of the seedling and mature plant of *P. peltatum* is given in Mr. Holm's interesting memoir,[24] to which I must refer readers who wish for fuller detail. Owing to his kindness in sending me seeds, I have been able to examine the first-year seedling anatomically.

As in *Eranthus hiemalis*, the blades only of the cotyledons are distinct. Their petioles are united into a long tube, the base of which is beneath the surface of the soil. The hypocotyledonary axis is vertical and very short, but not swollen into a tuber. Its tissues are packed with starch. It is terminated

[21] SARGANT, E., *l. c.*, pp. 57–61, and *pl. 6*.

[22] SCOTT and SARGANT. The development of *Arum maculatum* from the seed. Annals of Botany **12**: 404–413. 1898.

[23] JOST, Die Erneuerungsweise von *Corydalis solida* Sm. Bot. Zeit. **48**: 257. 1890.

[24] HOLM, TH., *Podophyllum peltatum*. BOT. GAZ. **27**: 419. 1899.

above by the cotyledons and next year's bud; below by the primary root which is large, stout, and branched. At the end of the first year the stem bud is set free underground by the withering of the cotyledons, and in the following spring it throws up a single green member and adds a few very short internodes—separated by scale leaves—to the squat vertical axis underground. This axis is again terminated by a bud which will develop in the third season.

The plant continues to grow in this fashion for several seasons. Each year's period of activity adds a few very short internodes to the vertical subterranean axis and produces several scale leaves, together with one or two foliage leaves. At the end of four or five years a season comes in which the terminal bud remains dormant. The bud which develops is found at the end of a horizontal rhizome produced in the previous season from the axil of a scale leaf; it resembles the terminal bud in structure and in the leaves it bears. The flower-bearing stem arises from the axil of one of the upper leaves of such a bud.

The bundles of the flower-bearing stem and of the vertical axis are arranged in the scattered fashion characteristic of monocotyledons. The whole structure of the plant indicates that this is primarily due to the number of leaf traces entering an axis so greatly reduced in length. Within the lateral rhizome—which possesses elongated internodes and bears small scale leaves—the bundles are arranged in a single circle. The number of traces entering the axis from a single foliage leaf is indicated in *figs. 6* and *7* (Holm, *l. c.*, pp. 425–6). Cambial layers exist within each bundle, but the bundle sheaths are thick-walled, and there is no interfascicular cambium.

Thus in Podophyllum partially united cotyledons and a close approach to monocotyledonous stem anatomy are found in connection with the geophilous habit. The genus must be fairly ancient, as indicated by its rather isolated systematic position and the distribution of its species. Four are included in the *Index Kewensis*. One is found in the Himalayas, two in China, and the fourth in North America. Possibly it reproduces some of the characters found in an ancestor which had become some-

what differentiated from the primitive stock of angiosperms by adaptation to a geophilous habit, and was thereby tending to a monocotyledonous structure.

The development of the embryo within the embryo sac of monocotyledons has already been described at some length, and the value of the phylogenetic argument based on it has been criticised. Nevertheless, since great importance has been attached to the apparently terminal position of the single cotyledon, it is worth while to consider how the facts appear from a new standpoint. If the cotyledonary member be derived from the two cotyledons of an ancestor, its rudiment cannot be really terminal, but must represent the congenital fusion of two lateral members. The terminal position is readily understood by comparison with such a seedling as that of *Delphinium nudicaule* (*figs. 1* and *2*).

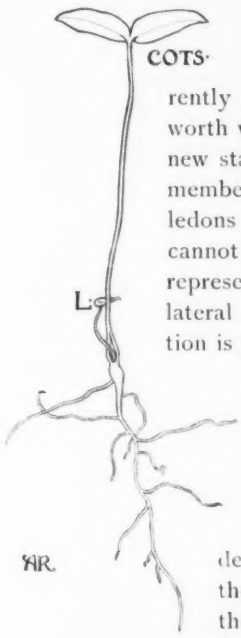

FIG. 1.—*Delphinium nudicaule*. Seedling eight weeks after seed was sown.

In this species the leafy stem bud develops in the same season as the cotyledons, and so soon as the first leaf attains any size it breaks through the cotyledonary tube near its base. For a short time this leaf appears to be laterally inserted on the cotyledonary axis (*fig. 1*), but as the leafy stem develops the cotyledons are pushed to one side, and then appear as a single lateral member (*fig. 2*). These errors are easily corrected; the stem bud is seen to be terminal, and the tube of the united cotyledons a fusion of two lateral members.

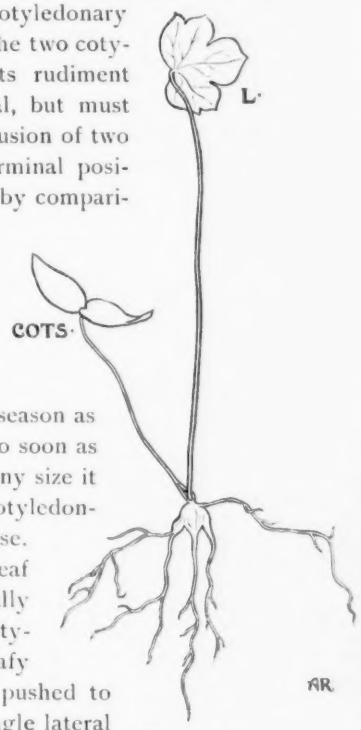

FIG. 2.—*Delphinium nudicaule*. Seedling fourteen weeks after seed was sown.

Now, suppose the cotyledons to become completely united by both margins, and that in the end this union is congenital. In order to develop freely, the stem bud must make its appearance at one side of the united members. As a rule, the cotyledons are differentiated some time before the growing point of the stem appears; in this case the single rudiment which represents both cotyledons is naturally formed in a straight line with the suspensor and the future axis. The rudimentary plumule when formed is forced to take up a lateral position (Alisma. *fig. 3*). As a rule, it attains the terminal position after germi-

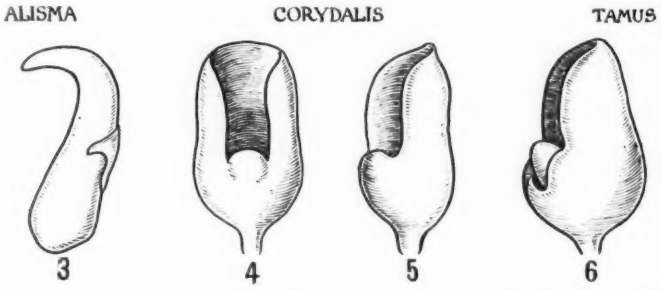

FIG. 3. *Alisma Plantago* (after HANSTEIN). FIGS. 4–5. *Corydalis cava* (after SCHMID); *fig. 4*, front view; *fig. 5*, side view. FIG. 6. *Tamus communis* (after SOLMS-LAUBACH).

nation, forcing the cotyledonary member to one side. In Tamus and Commelyna the growing point of the stem appears terminal, the cotyledonary rudiment lateral, from the first[25] (*fig. 6*).

The single cotyledon in the ripe seed of *Corydalis cava* strikingly resembles that of Tamus in form and position (cf. *figs. 4* and *5* with *fig. 6*). The simplest explanation of both structures is that they represent the fusion of two ancestral cotyledons, but that on account of the early formation of the rudimentary plumule, or perhaps because the cotyledons have united by one margin only—as in *Ranunculus Ficaria*—the stem bed has never lost its terminal position.

This hypothesis accounts for the structure of the monocotyledo nous embryo in a very simple way, and avoids the difficulty of

[25] SOLMS-LAUBACH, Ueber monocotyle Embryonen mit scheitelbürtigem Vegetationspunkt. Bot. Zeit. **36**:65. 1878.

supposing its single cotyledon to be a terminal leaf—a difficulty so formidable that the supporters of its terminal character have been obliged to assume that cotyledons are not true leaves, but organs *sui generis*. Their structure lends no support to this view.

The other characters which separate monocotyledons from dicotyledons are by no means so constant as the three already discussed; namely, the single cotyledon, the stem-anatomy, and the development of the embryo. Parallel venation of leaves, short duration of the primary root, and albuminous seeds are characters neither universal among monocotyledons nor confined to them. They are found in geophilous plants of both classes, though far more general among monocotyledons.

The value of these three subordinate characters as evidence in favor of the geophilous origin of monocotyledons is somewhat lessened by the consideration that they are found mainly—not exclusively—among geophilous genera within that class. They may be considered direct adaptations to the mode of life adopted by the species of their more recent ancestors, rather than an inheritance from geophilous ancestors common to all monocotyledons. The presence of all three characters among the palms, however—a family composed exclusively of trees—cannot be explained by recent adaptation to geophily. I shall return shortly to the evidence for the descent of all palms from a geophilous ancestor.

The trimerous symmetry of the flower is a very important character of monocotyledons, particularly to those botanists who derive the simpler flowers of the Aroideae, Gramineae, Palmae, and other orders from the more elaborate, considering their simplicity as due to the reduction of the floral parts. But I can discover no grounds for considering the trimerous flower as an adaptation to geophily. There may be an unsuspected connection, or the prevailing floral symmetry of monocotyledons may be an inheritance from the ancestral stock. A trimerous calyx and corolla is not uncommon among the Ranales.

To sum up, of the seven characters mentioned as distinguishing monocotyledons from dicotyledons, four have been shown to

occur frequently among geophytes and to be useful to the plant growing under conditions which determine the geophilous habit. They are therefore in all probability adaptations to that habit. Two more—the stem-anatomy and the apparently terminal cotyledon in the embryo—may be considered as direct consequences of such adaptations; the stem anatomy acquiring its peculiar features from the insertions of numerous broad-based leaves on a squat subterranean axis, and the embryonic cotyledonary member arising from the congenital fusion of two ancestral cotyledons. The seventh character—trimerous floral symmetry—bears no obvious relation to the geophilous habit, but is not inconsistent with it.

In a paper read before the Linnaean Society in 1892, Mr. Henslow[26] maintains that monocotyledons were derived from dicotyledons by an adaptation to an aquatic habit. He bases his argument on the large proportion of monocotyledons which are aquatic, and on the nature of the characters, external and internal, which distinguish them from dicotyledons. These are on the whole, he suggests, the characters of water plants. He considers the single cotyledon as representing one of the dicotyledonous pair, the other having disappeared.

Other botanists have suggested the derivation of monocotyledons from an aquatic or amphibious ancestor. Some of their characters would bear this interpretation, and indeed aquatic plants have several features in common with geophytes. The main axis of the great majority of water plants is hidden in the mud of the river or lake bed, and the green parts in the colder climates die down on the approach of winter. The subterranean stem is commonly a rhizome, but it bears upright buds. When broad-based leaves are inserted on the shortened axis of such a bud, their traces might naturally be arranged in the scattered fashion actually found among the Nymphaeaceae (Henslow, *l. c.*, p. 512) and monocotyledons. But, on the other hand, the tendency of an aquatic habit is to reduce the vascular tissue altogether; the leaf traces may almost disappear, and the vascu-

[26] HENSLOW, G., A theoretical origin of endogens from exogens by self-adaptation to an aquatic habit. Linn. Soc. Journ. **29**: 485. 1892.

lar system of the submerged stem be reduced to a slender central stele with hardly any lignified elements.

There are aquatic species with parallel-veined leaves (as Vallisneria, Zostera), but this character is not common among water plants. It is almost confined to the monocotyledons among them. Circular or oval floating leaves, or the much dissected submerged leaves, are far more frequent.

The primary root of aquatic plants is often replaced early by tufted adventitious roots, a character found in many land plants with creeping rhizomes.

On the other hand, aquatic dicotyledons show no tendency to the formation of a single seed leaf in place of two, nor do they always possess albuminous seeds.

Great stress has been laid on the primitive floral structure displayed by many aquatic monocotyledons. Among the Heliobiae more than two whorls of stamens, and more than one whorl of carpels are not uncommon (Stratiotes, Hydrocharis, and others). Both stamens and carpels are occasionally indefinite in number and arranged spirally on the thalamus (Alisma, Limnocharis, and others). It is very probable that such types reproduce the floral symmetry of ancestors which were intermediate in character between the Ranales and the Liliiflorae. But even if some primitive characters are retained by aquatic species, it does not follow that the primitive monocotyledon lived in the water, and that its descendants acquired their peculiarities by adaptation to that habit. It is more probable that the aquatic forms represent ancestors of our modern monocotyledons which were crowded out by the competition on land, and took refuge in the water, or on its edge, where competition was less severe.[27] The vegetative structure of such species would be modified by the change of environment and would no longer represent that of the ancestor, but the reproductive organs might well remain unchanged. Such ancestors, if geophilous, would readily adapt themselves to amphibious conditions; their underground stems creeping in the mud which fringed the pond or stream until by

[27] Cf. Darwin on the survival of ganoid fishes and simple vertebrates (Origin of Species, Sixth Ed. 1:130, 154, 155, 163; 2:99, 173. 1888.

degrees they grew beneath the water and sent up shoots more and more completely modified to an aquatic habit.

It has been objected that plants highly specialized to a particular mode of life, such as geophytes, are unlikely to give rise to a race so numerous and of such diversified form as monocotyledons. But the geophilous habit of a plant may be marked without any such profound modification in its structure as would destroy its capacity for adaptation to changed conditions. A geophyte is—as already suggested—particularly well suited to become amphibious. It acquires the climbing or twining habit with hardly less ease. *Bryonia dioica* and *Tamus communis*, two of our commonest perennial climbers, have very large tuberous rootstocks. Among the 187 genera mentioned in Bentham and Hooker's *Genera Plantarum* as belonging to the order Liliaceae, sixteen are mentioned as including species with a climbing or twining stem. Of these I find that eleven possess underground stems; rhizomes, tubers, or even bulbous, in the mature condition. Species from two of the remaining five I have examined as seedlings, and the rudiments of a tuber are very clear. Concerning the underground organs of Rhipopozon, Semele, and Behnia I have no information.

The absence of a normal cambium, which follows from the assumption of the geophilous habit, is certainly unfavorable to the production of trees. The want is occasionally supplied by the formation of anomalous thickening-rings (Aloe, Dracaena, etc.), but among the palms no such expedient is found. Without it they manage to grow into trees of great size in tropical and semitropical countries. Is it possible to trace the palms back to a geophilous ancestor?

Seedling palms are easily obtained, as they are much grown as pot-plants for indoor decoration. At this immature period of life they have many geophilous features. In the young seedling the hypocotyl is always short and commonly somewhat enlarged. The cotyledon sheathes the plumule more or less completely with its broad base. The first leaf of the stem bud is never more than a sheath; it is sometimes followed by one or two like itself before the first foliage leaf appears.[28] The stem at this time and

[28] MICHEELS, H., Recherches sur les jeunes Palmiers, *etc.* 105. Liège. 1889.

for many years later is a squat axis surrounded by successive leaf bases. The primary root is vigorous and persists for some time, but in the end it is always replaced by a number of much stouter cauline roots. In fact, if a young palm, such as is commonly sold for table decoration, be halved longitudinally, it is seen to be formed on the model of a bulbous plant. Its structure in youth may certainly be interpreted as a reminiscence of geophilous ancestry.

CONCLUSION.

In this account of a new view on the evolution of monocotyledons, I have tried to show that it is the most consistent—as in practice I have found it the most suggestive—among existing hypotheses.

An immense amount of work remains to be done on the structure, both external and internal, of seedlings before this or any other suggestion can be generally accepted as representing, even in outline, the real sequence of events. We need observers to carry on the work so well begun by Irmisch; monographs like those of Mr. Holm on Podophyllum and Erigenia; the detailed work of anatomists like Professor Jeffrey and M. Quéva. Even if no direct evidence should be contributed from the geological record, there is little doubt that the key to the descent of monocotyledons will be found in their morphology.

QUARRY HILL, REIGATE, ENGLAND.

THE NUTRITION OF THE EGG IN ZAMIA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LVI.

ISABEL S. SMITH.

(WITH SIX FIGURES)

FOR some time previous to the cutting off of the ventral canal cell, the central cell in most gymnosperms is surrounded by large prominent cells called the "jacket cells," which contain particularly large nuclei. The inner walls of the jacket cells, in contact with the egg, are pierced by numerous pores (*fig. 2*). During the rapid growth of the central cell the jacket cells and their nuclei are prominent; but during the period of free nuclear division in the embryo the jacket becomes less conspicuous, and finally becomes indistinguishable as a definite nutritive layer. It is evident that the jacket cells contribute to the growth of the central cells, and afterward to the growth of the egg and proembryo. The passage of various contents of the jacket cells into the egg has been described by several observers.

Goroschankin (**4**) says in regard to Ceratozamia: "In fresh preparations mounted in water, each canal is seen to be filled with fine protoplasm that passes over sometimes into the protoplasm of the neighboring cells and sometimes into the protoplasm of the egg cell. Transverse and longitudinal sections of fruits which were carried up with strong alcohol showed me the following: under the action of the alcohol the protoplasm of the surrounding endosperm sheath seems wholly smooth or with scarce observable projections on the side nearest the egg. But as for the protoplasm of the egg, it appears covered with projections the length of which equals nearly or wholly the length of the canals. Afterward I began to make tangential sections of the egg from alcoholic preparations. Now I was able to see the sieve plates in the canal. . . . . From my observations on the egg wall in the cycads, the following conclusions were reached:

the wall is formed of cellulose and contains a large number of canals showing genuine sieve plates, through which the protoplasm of the cells of the endosperm layers communicates with the protoplasm of the egg."

Ikeno (**5**) in his paper on *Cycas revoluta* says: "Since Goroschankin's researches it is known that in the cycads the protoplasm of the central cell and of the wall cells are in close connection by means of protoplasmic threads. It is easy to see that the material filling the nuclei of the wall cells, which in its natural condition is a half-fluid substance, flows out from there and goes to the central cell through these intercellular breaks. Indeed, I can find various stages of the transportation of this material to the central cell, showing as granulations in fixed material, where these granules lie just outside the nuclei, then in the protoplasmic threads themselves, then in the central cell directly before the protoplasmic break. Also one finds a large mass of these granulations at the edge of the central cell, which have collected there, evidently coming completely from the neighboring wall cells."

Arnoldi claims that the nuclei of the jacket cells pass bodily into the egg through the large pores in the inner walls of the jacket cells. In writing of *Pinus cembra* he says (**2**): "I can show that I could observe out of a series of sections more than one hundred and fifty nuclei passing out of the jacket cells. It is also established through my observations that the small proteid vacuoles described by Goroschankin as Hofmeister's nodules are only nuclei passing out of the jacket cells."

In writing on *Cephalotaxus Fortunei* he says (**1**): "In the first stages of development of the jacket cells we find the little nucleoli only half inside of the nuclei. In some later stages we find them also in the protoplasm of the jacket cells. Since these small granules are fully equal to those in the nuclei in all relations of size, staining ability, etc., since they are first observed in the nucleus and later in the protoplasm, we may conclude that they pass from the nuclei into the protoplasm. In the protoplasm of the jacket cells they are heaped up in great masses, and then pass over into the egg cell. The nodules appear in the

cell on the side in which the protoplasm itself is rich in vacuoles. Observation of the passage of the granules from the jacket cells into the egg is most difficult. The egg cell and the jacket cell walls with the highest magnifications show no holes. But since on both sides of the wall we find granules of a like nature, we must admit a process of passing over. If one admit that we have not small bodies, but small drops of a viscid fluid substance, filtration furnishes an explanation for the passing over."

Murrill (**8**) in his paper on Tsuga writes: "I cannot confirm for Tsuga the results of Arnoldi's recent studies (1900) on the proteid vacuoles of the Abieteae. It may be that further search on my part will reveal the passage of the nuclei of the sheath cells into the central cell, but very careful examination of numerous archegonia in all stages of development has thus far failed to show a single undoubted example of such passage. I find the nuclei of the sheath cells streaming profusely at times, as described by Ikeno (1898) for Cycas, and observe collections of granules in the outer vacuoles of the central cells which very much resemble the sheath nuclei; but the sheath cells are never found without their nuclei. The sheath remains one-layered, though its cells often divide as the archegonium grows. At points where the archegonia come into close contact, the sheath is frequently crushed and destroyed; but throughout most of its extent the cells and their nuclei continue active during the life of the archegonium."

Strasburger (**6**) upon re-examining Pinus failed to confirm Arnoldi's views. Margaret C. Ferguson (**3**) alludes to Arnoldi's study of Pinus, but fails to confirm the migration of the nuclei of the sheath cells into the egg. Land (**7**) in describing Thuja writes: "Protoplasmic connections between the jacket cells and the central cell were not seen, but it is possible they were overlooked owing to the extreme thinness of the dividing wall. It is not believed that the nuclei of the jacket cells pass into the central cell as reported in Caphalotaxus by Arnoldi."

Material of *Zamia floridana* was secured from Miami, Florida. The earliest stages studied showed the central cell of the archegonium before the mitosis which gives rise to the egg and the

ventral canal nucleus. From this point up to the organization of embryos in which the cotyledons were beginning to appear the series was fairly complete.

During the earlier growth of the central cell no jacket is distinguishable, and during this time also the contents of the central cell are scanty and much vacuolated. As the central cell approaches its mature size and begins to fill with nutritive substances, the jacket appears and soon becomes very conspicuous, its single layer of cells being rich in protoplasm, but almost destitute of starch, while the cells surrounding it are nearly filled with large starch grains (*fig. 1, j, s*). This condition continues during the later growth of the central cell, during the growth of the egg, and even during the earlier stages in the development of the embryo. During their entire period the mode by which materials pass from the jacket into the interior is the same. All the figures are from stages between the formation of the ventral canal nucleus and fertilization.

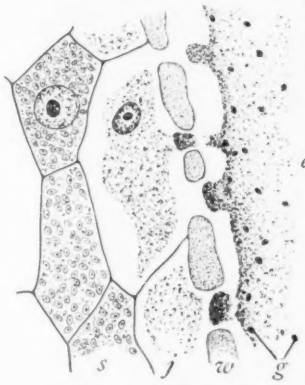

FIG. 1.—*Zamia floridana*. Portion of egg, *e*, jacket, *j*, and neighboring cells; two of the four haustoria shown are broken off; haustoria discharging contents into egg; *g*, granules passing from the haustoria into the egg; *s*, starch-containing cells outside jacket; *w*, thick inner walls of jacket cells.

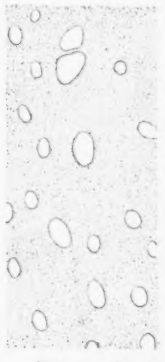

FIG. 2.—*Zamia floridana*. Portion of inner surface of jacket showing numerous pits of various sizes.

The inner walls of the jacket cells become very much thickened (*figs. 1, 3–6, w*) and are pierced by numerous pores of various sizes, as shown in surface view in *fig. 2* and in section in all the other figures. Through these pits the protoplasm of the egg protrudes into the jacket cells, forming haustoria-like processes. After passing through the pits, the ends of the haustoria become distended so that the structure appears knob-shaped. The contents of the haustorium

vary, and the variation is accompanied by striking variations in the staining reactions, sometimes the end of the projection appearing as a dense, deeply staining knob in which scarcely any structure can be distinguished, and sometimes staining faintly and showing beautifully the cytoplasmic reticulum. In fact, the haustorium behaves like a gland cell, during the period of accumulation staining more and more deeply, then discharging, and during the following period of exhaustion staining faintly until the active period begins again. In *fig. 1* the haustoria are discharging, the granules (*g*) coming undoubtedly from the haustoria. The appearance of the haustoria during the period of exhaustion following the discharge is shown in *fig. 3*, *h*.

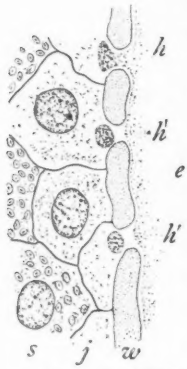

FIG. 3.—*Zamia floridana*. Period of exhaustion; *h*, haustoria; *h'*, tangential sections of the swollen ends of haustoria which might be mistaken for nuclei; *e*, peripheral portion of egg; *j*, jacket cells; *s*, starch-containing cells outside jacket; *w*, thick inner walls of jacket cells.

That the contents of the jacket cells are strongly attracted toward the haustoria is easily seen during the entire period of accumulation. In *figs. 1*, *4*, and *6* the protoplasm is shown streaming toward the haustoria, and in *fig. 4*, as is often the case, even the nucleus appears to be drawn out toward the haustorium. During the period of exhaustion (*fig. 3*) no such streaming of the protoplasm or distortion of the nuclei was observed.

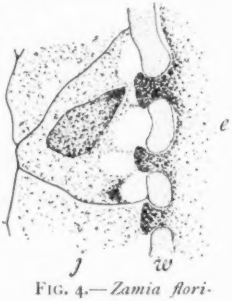

FIG. 4.—*Zamia floridana*. Streaming of cytoplasm toward haustoria; nucleus much drawn out; *e*, peripheral portion of egg; *j*, jacket cells; *w*, thick inner walls of jacket cells.

In no case was there any indication of the passage of nuclei or nucleoli from the jacket cells into the egg, and in no case did we find a jacket cell without a nucleus. However, that material is probably drawn from the nuclei as well as from the cytoplasm may be seen by comparing the nuclei of *figs. 1* and *6* with those of *fig. 3*, the former showing the active condition and the latter the exhausted condition following the discharge.

In preparations the haustoria are often broken off (*figs. 1* and *6*), and in this condition they might be mistaken for material passing in large masses from the jacket cells into the egg. This condition resembles that shown by Ikeno for *Cycas revoluta*. Possibly his figures may bear this interpretation; at least it would be worth while to re-examine Cycas with this in mind.

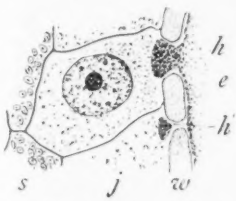

FIG. 5.—*Zamia floridana*: *e*, peripheral portion of egg; *h*, *h'*, haustoria, the lower a tangential section of the knob-like end which might be taken for a nucleolus; *j*, jacket cells; *s*, starch-containing cells outside jacket; *w*, thick inner walls of jacket cells.

It often happens that the knob-like ends of haustoria are cut in a longitudinal tangential plane. In such cases they closely resemble nuclei (*figs. 3* and *5*, *h'*), and then they might be mistaken for nuclei passing bodily into the egg. Whether such a mistake would be sufficient to explain Arnoldi's account still remains to be seen.

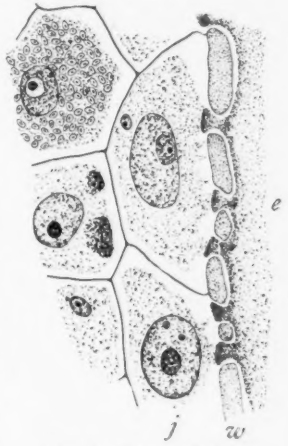

FIG. 6.—*Zamia floridana*. Streaming of cytoplasm toward haustoria; *e*, peripheral portion of egg; *j*, jacket cells; *w*, thick inner walls of jacket cells.

No sieve plates or similar structures, as described by Goroschankin, were observed in any of the preparations.

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A CONTRIBUTION TO THE LIFE HISTORY OF ASTER.

MARIE OPPERMAN.

(WITH PLATES XIV AND XV)

MATERIALS AND METHODS.

THIS study is based upon an investigation of *Aster undulatus*, *A. multiflorus*, *A. Novi-Belgii*, and *A. Novae-Angliae*. Flowers in various stages of development were collected. The buds were halved, the smaller heads were cut into thirds, and the larger into quarters. The upper portion of the floral envelopes together with the inclosed styles and stamens were cut away, great care being exercised not to injure the ovules. Two fixing fluids were used, Flemming's chrom-osmo-acetic acid mixture and chrom-acetic acid, both giving good results. After dehydration the material was brought gradually, through ascending grades, into either cedar oil or chloroform before infiltration with the paraffin. So far as a study of my material goes, it is a mere matter of convenience whether cedar oil or chloroform be used in the process of imbedding, as the results obtained by either method were equally satisfactory. Sections were cut 10μ thick and stained in Flemming's safranin, gentian-violet, and orange combination, or in Heidenhain's iron-haematoxylin. When Flemming's triple stain was used, it was necessary to allow the slides to remain for several hours in the gentian-violet, since this stain is rapidly removed during the process of dehydration in Aster. It was found advantageous to place the slides in xylol before mounting in balsam. With this treatment the sections cleared more quickly, and were therefore ready for study in a shorter time than when mounted directly from the bergamot oil.

This investigation was carried on in the Botanical Laboratory of Wellesley College, under the direction of Dr. Margaret C. Ferguson, to whom I desire to express my gratitude for her invaluable counsel and unceasing interest and encouragement.

THE DEVELOPMENT OF THE EMBRYO SAC.

The embryo sac arises from the lowest cell of an axial row of four cells, that is, from the cell most distant from the micropyle. The mother-cell of the embryo sac grows rapidly, soon becoming strongly differentiated from the surrounding cells. At some time during the early stages of development, the nucleus of the macrospore moves to the micropylar end of the spore and there divides. The embryo sac contains very little cytoplasm at this stage, with the exception of the dense mass around its nucleus (*fig. 1*). It agrees in this respect with the young embryo sac of Silphium, as described by Merrell (1900), and differs from Lilium and some other plants in which the embryo sac is densely filled with cytoplasm at the time of the first nuclear division.

In *A. multiflorus* the young embryo sac reaches an advanced stage of growth at the time of the first division of its nucleus, and does not show a very great increase in size subsequent to its binucleate stage. In the other species studied, however, the embryo sac does not assume its ultimate form until about the time of the fusion of the polar nuclei. After the division of the macrospore nucleus, one of the resulting nuclei moves toward the opposite or lower pole. In the meantime the embryo sac continues to grow in length, but increases very little, if any, in breadth. At the time of the second nuclear division, the embryo sac is long and somewhat cylindrical in outline. Here, as in other angiosperms, the two nuclei divide simultaneously, the division occurring, in some cases at least, before the lower nucleus has reached the antipodal end of the sac (*figs. 2, 3*). In the embryo sac shown in *fig. 2* the second nuclear division is just completed, and the nuclei have not as yet separated. The four nuclei enter the complete resting stage, as shown in *fig. 3*, and then immediately divide again, giving rise to a typical eight-nucleate embryo sac.

At the time when the eight nuclei are formed, the embryo sac, as seen in vertical section, is more or less rectangular in outline, but from this stage on the two poles of the embryo sac may become strongly differentiated. The antipodal end shows

little or no increase in breadth, but elongates rapidly, pushing down for a considerable distance into the nucellus, while the upper and central region of the embryo sac ceases to elongate, but grows to several times its original breadth.

Considerable variation has been noted in the shape and size of the mature embryo sac, not only in the different species, but also in different ovules of the same species. These irregularities may be apparent at an early stage, as is shown in *figs. 2* and *3*. The embryo sac represented in *fig. 3*, although of the same species as the one represented in *fig. 2* and of a later stage of development, has grown much less in length. It is also apparent from a comparison of *figs. 6* and *7* that, while the embryo sac of *A. undulatus* shows a remarkable growth in breadth near the micropylar end, the embryo sac of *A. multiflorus*, though slightly older than the former, has broadened very little in that region. The upper portion of the embryo sac of *A. Novi-Belgii*, like that of *A. multiflorus*, grows little in breadth, while the form of the embryo sac in *A. Novae-Angliae* (*fig. 8*) resembles very much that of *A. undulatus*.

Soon after the embryo sac has reached the eight-nucleate stage of development, three of the nuclei in the lower end of the embryo sac move downward to form the cells of the elongated antipodal region. The four nuclei in the micropylar end assume their characteristic arrangement and give rise to the egg apparatus and to the upper polar nucleus. The egg nucleus rests in the lower oval end of a pear-shaped cell, in a dense mass of cytoplasm. Above the nucleus the usual vacuole is found, which is very large in Aster, often occupying two-thirds of the entire oosphere. The synergids lie one on each side or both on the same side of the oosphere. Each may have the same relative position with reference to the micropyle, or one synergid may extend farther into the micropyle than the other. They are usually densely filled with cytoplasm, but may be somewhat vacuolate. The nucleus of each synergid is much smaller than the egg nucleus or the upper polar nucleus, and may be placed centrally or at a point considerably above or below the middle of its cell.

Immediately after the organization of the egg apparatus, the polar nuclei move toward one another. The lower nucleus travels much faster than the upper one, so that they meet comparatively near the oosphere. The two take a position just beneath the egg, but in contact with it, and there fuse to form the endosperm nucleus. An early stage of fusion is illustrated by *fig. 6*, in which one polar nucleus appears closely pressed against the other. In *fig. 7* the membranes between the two fusing nuclei have already disappeared. The endosperm nucleus is very large, almost spherical in outline, and is furnished with a rather open reticulum and one large densely staining nucleolus. The fusion of the polar nuclei may be delayed, in some instances until the time of fertilization (*fig. 9*), but ordinarily the formation of the endosperm nucleus has taken place before the pollen tube discharges its contents into the embryo sac.

When the embryo sac is mature, it occupies about one-half the entire length of the nucellus. The lower two-thirds of the embryo sac consists of the narrow elongated antipodal cells. As a rule, the cells of the nucellus immediately surrounding the antipodals are empty and more or less irregular in outline. A general conception of the structure and position of the parts of the ovule at the time of the maturity of the embryo sac is given in *fig. 10*.

LATER HISTORY OF THE ANTIPODALS.

The antipodal portion of the embryo sac in dicotyledons has been found to vary greatly in the number, structure, and position of its cells. Chamberlain (1895) finds that the number of antipodals in *A. Novae-Angliae* ranges from two to thirteen, six or seven being the usual number. The lower antipodal was found to differ from the others in size, in the density of its cytoplasm, and in the appearance of its nuclei. He observes, however, that in one instance the contents of this cell bear a superficial resemblance to an egg and believes that it represents an antipodal oosphere. The number of nuclei in an antipodal cell was found to vary from one to over twenty. In my study of Aster I find that the antipodals in the species examined, although showing in no instance as many as thirteen cells, agree

closely, as to their structure, with Chamberlain's description, but they do not confirm the observations made by Martin (1892), who found only four antipodals. These four cells were never arranged in a single longitudinal row, and he did not figure them as separated by cell walls.

Definite cells appear in the antipodal region very early in the development of the embryo sac. As a rule, these cells have reached their greatest development when the embryo sac is ready for fertilization, but occasionally they continue to grow for some time after fertilization. It often occurs in *A. Novae-Angliae* and in *A. undulatus* that the lowest of the antipodal cells becomes very much enlarged (*figs. 11, 14, 16*). The nuclei of this cell were found in a few cases to be somewhat larger than the nuclei of the other antipodals, but in no instance was I able to find in this lowest cell an antipodal oosphere as described by Chamberlain (1895). However, an egg, doubtless derived from one of the upper antipodal nuclei, was observed and will be described later. In one preparation an embryo sac was found in which the lowest antipodal exceeded in width the expanded upper portion of the embryo sac, but there was nothing in the character of its nuclei to indicate the presence of an antipodal egg (*fig. 16*).

There seems to be no limit to the number of antipodal nuclei in Aster. Cells which contained only one nucleus were found in only a few cases. *Figs. 14* and *15* illustrate two antipodal cells, one of which contains fourteen nuclei of various sizes and the other nineteen small nuclei.

The antipodals persist until the embryo sac is in an advanced stage of development, and their function is probably that of conveying nutrition to the developing embryo. In several instances two or three cells just below the antipodals were observed to retain their normal appearance, containing cytoplasm and nucleus (*fig. 5*). It may be that these cells are active in supplying food to the developing embryo, as described by Ferguson (1901) in Pinus and confirmed by Coker (1902) in Taxodium.

FERTILIZATION.

Double fertilization has been found to occur in several Compositae and, judging from some of my preparations, it occurs also in Aster; but my material has yielded so few stages just before and including the fusion of the sexual nuclei that I do not wish to speak unqualifiedly regarding this point at present. In *fig. 9* we have an instance of the delayed fusion of the polar nuclei, and apparently an example of double fertilization in *A. undulatus*. The polar nuclei are in an early stage of fusion, and the sperm nucleus is pressed against the lower polar nucleus. The fusion of the sperm with the egg nucleus is nearly completed, so that the two appear almost as one nucleus with two nucleoli.

A most interesting embryo sac is illustrated in *fig. 18, a–b*. There can be no doubt that we have in this instance the occurrence of two oospheres and two endosperm nuclei in the same embryo sac. The upper part of the embryo sac resembles all normal embryo sacs at a similar stage of development; but in the lower portion, just above the first antipodal cell, there is a cell and a large nucleus which have the same structure and the same relative position as that of the egg and the endosperm nucleus at the micropylar end. These clearly represent, so far as position is concerned, an antipodal oosphere and a definitive nucleus.

No positive statement regarding the origin of this extra egg and endosperm nucleus can be made, but several theories as to their probable derivation may be suggested. It is possible that the lower polar nucleus did not fuse with the upper polar nucleus, but that each has taken on the appearance of an endosperm nucleus, and that the lower oospere has arisen directly from an antipodal; it may be that the normal egg has wandered to the antipodal region of the embryo sac, and that the upper egg has been derived from one of the synergids; or it is possible that the lower egg has developed from one of the synergids which had become displaced. In order to explain satisfactorily the structure of this embryo sac on the basis that one of the eggs has been derived from a synergid, it is necessary to assume that at least three irregularities have occurred in its development.

Moreover, the two small nuclei at the micropylar end of the embryo sac doubtless represent the synergids, now in a state of disintegration. Therefore, it seems to the writer most improbable that either egg had its origin in a synergid. I am aware that one of the two nuclei just above and at one side of the upper egg may represent the tube nucleus, but we have no direct evidence that such is the case, and it has not yet been demonstrated that the tube nucleus enters the embryo sac in Aster. Judging from the structure of the micropylar end of this embryo sac and from the position of the unusual nuclei, the most probable, and also the most simple interpretation of this phenomenon is that the upper egg apparatus was formed in the usual way, and that the lower egg and the endosperm nucleus associated with it were derived from one of the three original antipodal cells.

We have here not only the remarkable occurrence of a distinctly outlined egg associated with a large definitive nucleus in the antipodal region of the embryo sac, but also the interesting phenomenon of the fertilization of that egg. Whether a sperm nucleus has already fused with the upper egg or with the endosperm nucleus cannot be ascertained. One of the sperm nuclei, however, has passed to the lower part of the embryo sac to fuse with the lower oosphere. The sperm is more or less banana-shaped and is just pressing itself against the cytoplasm of the egg. It has somewhat the appearance of the sperm nuclei of *Paris quadrifolia*, as described in the recent paper of Ernst (1902).

This discovery of an antipodal functioning as an egg and about to be fertilized is a very significant fact, and has an important bearing on the problem of the homologies of the antipodals. It has been shown by different investigators that all the nuclei of the embryo sac except the antipodals are capable of being fertilized and may therefore be considered as potential eggs. As already stated, Chamberlain (1895) reports the occurrence of a nucleus in the enlarged end cell of the antipodals, which he believes to be an oosphere, formed by one of the nuclei of the antipodal region surrounding itself with cytoplasm, and he suggests that we need only to observe an actual case of fertiliza-

tion in this region to demonstrate the egg-like nature of these cells. Tretjakow (1895) reports an instance in which he finds an embryo in the antipodal region, but as he did not find fertilization he believed the embryo to have arisen apogamously.

Of the two views held as to the homologies of the antipodals, namely, that they represent either a vegetative prothallus or that they are potential eggs, the discovery of the fertilization of an antipodal egg adds substantial evidence to the theory that all the cells of the embryo sac are potential eggs. If the antipodals are potential eggs, then it would seem that the fusion of one sperm nucleus with the two polar nuclei is, as Nawaschin and some other investigators believe, a true act of fertilization.

After fertilization the egg nucleus becomes spherical but does not divide until sometime subsequent to the first division of the endosperm nucleus. The first division of the egg is transverse, as usual, and the subsequent development of the embryo differs little from that of other Compositae.

SUMMARY.

The embryo sac arises from the lowest cell of an axial row of four cells.

The eight-nucleate embryo sac is formed in the usual manner.

Great variation is shown in the form of embryo sacs, both in different species and in the same species.

The polar nuclei fuse ordinarily before fertilization, but may fuse after it.

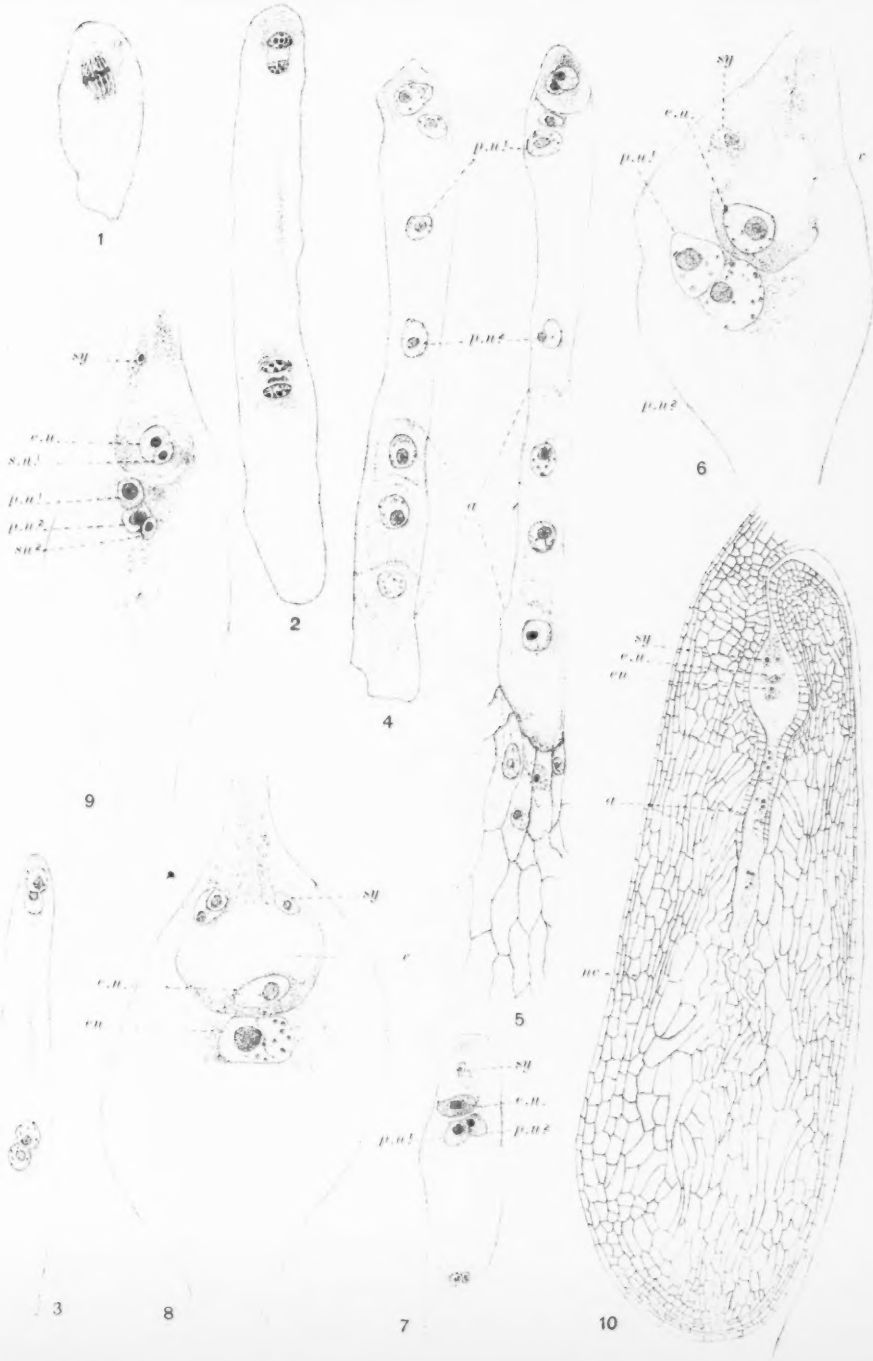
The endosperm nucleus is marked by its very large size, its almost spherical shape, its large nucleolus, and its position below and in contact with the oosphere.

The antipodals show a remarkable growth before the time of fertilization and persist very late in the development of the embryo.

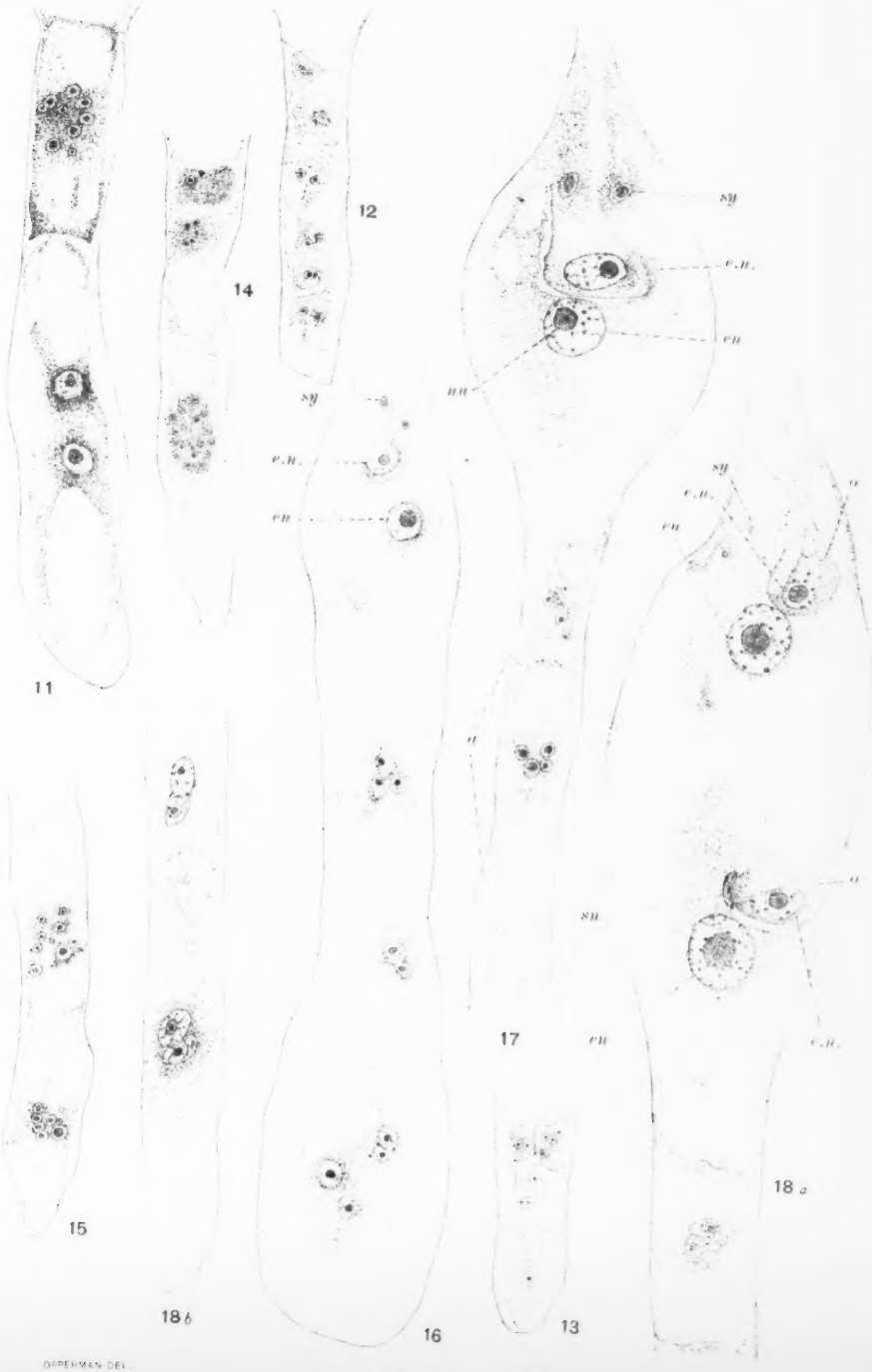
From one to nineteen nuclei were found in a single antipodal cell.

The lowest antipodal cell in *A. undulatus* and *A. Novae-Angliae* is often very much enlarged.

The fertilization of an antipodal egg is clearly demonstrated in Aster.



OPPERMAN on ASTER.



OPPERMAN on ASTER.

Double fertilization was observed in *A. undulatus*.

The sperm nuclei assume the structure of ordinary nuclei at the time of their fusion with the egg and the endosperm nucleus.

The development of the embryo follows the type described for other Compositae.

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EXPLANATION OF PLATES *XIV AND XV*.

All figures were drawn with a Nachet camera lucida and are reduced one-fourth in reproduction. The portion of a figure nearest to the micropylar end of the ovule is always toward the top of the plate. The lettering of the figures is to be interpreted as follows: *e.n.* egg nucleus; *o*, oosphere; *sy*, synergids; *p.n.*[1] upper polar nucleus; *p.n.*[2] lower polar nucleus; *nu*, nucleolus; *en*, endosperm nucleus; *s.n.*[1], *s.n.*[2] sperm nuclei; *a*, antipodals; *nc*, nucellus; *v*, vacuole.

FIG. 1. *A. multiflorus*. A young embryo sac with its nucleus in the metaphase of division. × 600.

FIG. 2. *A. undulatus*. A young embryo sac in the two-nucleate stage; the nuclei are in the telophase of division. × 600.

FIG. 3. *A. undulatus*. A four-nucleate embryo sac just after the second nuclear division. × 600.

FIG. 4. *A. Novae-Angliae*. An eight-nucleate embryo sac; the three antipodal cells have just been laid down; the egg apparatus is being formed

in the micropylar end; the polar nuclei are moving toward one another. × 600.

FIG. 5. *A. Novae-Angliae.* An eight-nucleate embryo sac; the egg apparatus is not yet formed; the polar nuclei are some distance apart; three active nuclei lie in the nucellus below the antipodal region. × 600.

FIG. 6. *A. undulatus.* The polar nuclei in the first stage of fusion. × 600.

FIG. 7. *A. multiflorus.* The polar nuclei in a more advanced stage of fusion. × 600.

FIG. 8. *A. Novae-Angliae.* A mature embryo sac. × 600.

FIG. 9. *A. undulatus.* An embryo sac in which the fusion of the polar nuclei has been delayed and double fertilization is taking place. × 600.

FIG. 10. *A. undulatus.* A mature embryo sac showing the structure of the surrounding nucellar tissue. × 140.

FIG. 11. *A. Novae-Angliae.* The antipodal region of a mature embryo sac, showing a long somewhat enlarged lower cell with two large nuclei. × 600.

FIG. 12. *A. multiflorus.* The antipodal region of a young embryo sac, showing six cells. × 600.

FIG. 13. *A. multiflorus.* The antipodal region of a young embryo sac, showing two of its cells lying side by side. × 600.

FIG. 14. *A. undulatus.* The antipodal region of an older embryo sac; the lowest cell is enlarged and contains nineteen small nuclei. × 600.

FIG. 15. *A. Novae-Angliae.* The antipodal region of a mature embryo sac showing multinucleate cells. × 600.

FIG. 16. *A. undulatus.* An embryo sac with an enlarged antipodal cell. × 600.

FIG. 17. *A. undulatus.* A normal mature embryo sac. × 600.

FIG. 18, *a. A. undulatus.* An abnormal mature embryo sac, containing an antipodal endosperm nucleus and also an antipodal oosphere which is about to be fertilized by a banana-shaped sperm. × 600.

FIG. 18, *b.* The antipodal cells of the embryo sac in *fig. 18, a.*

NEW OR UNRECORDED MOSSES OF NORTH AMERICA. II.[1]

J. CARDOT and I. THÉRIOT.

(WITH PLATES XVI–XXV)

Phascum hyalinotrichum Card. & Thér., sp. nova.—Plantulae minimae, pusillae, gemmaceae, solitariae vel gregariae, pallide virides. Folia imbricata, inferiora brevia, superne majora, media superioraque ovata, 0.8–1 mm longa et 0.6 mm lata, concava, acuminata, integra vel subintegra, marginibus undique planis vel inferne leniter reflexis, costa angusta, 24 μ in medio folii crana, inferne attenuata, in cuspidem piliformem, flexuosam, hyalinam, tertiam vel dimidiam partem folii aequantem excurrente, rete laxo, omnino-laevi, parum chlorophylloso, pallide viridi, superne hyalino, cellulis mediis irregularibus, quadratis, breviter rectangulis vel subhexagonis, long. 18–30 μ, lat. 12–18 μ, parietibus crassiusculis, inferioribus majoribus, parietibus tenerrimis, superioribus longioribus, parietibus incrassatis. Capsula in pedicello perbrevi, 0.2 mm longo, geniculato, immersa, globosa, apiculata, diam. 0.7 mm. Calyptra cucullata, dimidiam partem capsulae obtegens. Sporae maturae ignotae. *Plate XVI.*

California: Soldier's Home, Los Angeles county (Dr. Hasse, 1902; herb. C. F. Baker).

A quite peculiar species, very distinct by its habit, which recalls that of an Acaulon, its puliform excurrent nerve, and its loose smooth areolation, a little chlorophyllose below and hyaline above.

Pleuridium Bakeri Card. & Thér., sp. nova.—Humile, laxiuscule cespitosum, viridi-lutescens. Caulis 2–4 mm altus, erectus, simplex. Folia erecta, inferiora minuta, remota, brevia, superiora longiora, lanceolato-subulata, acuta, integra, rarius apice subdenticulata, marginibus inflexis subcanaliculata, 1.3 mm longa, 0.35 mm lata; perichaetialia duplo longiora, sensim subulata; costa lata (80–100 μ), percurrens, in foliis perichaetialibus paululum angustior; cellulae inferiores pellucidae, subrectangulae, 24 μ longae,

[1] See for No. I, BOT. GAZ. 30: 12. 1900.

12μ latae, mediae superioresque angustiores, 29–30μ longae, 5μ latae, opacae, parietibus incrassatis. Capsula in pedicello erecto, brevi, 0.4^{mm} longo, immersa, ovata, leniter gibbosa, obtusissime apiculata, laevis, matura fusco-lutescens, 1^{mm} longa, 0.6^{mm} crassa. Calyptra cucullata, tertiam dimidiamve partem capsulae obtegens. Sporae elliptico-subglobosae, minutissime papillosae, 24–30μ crassae. Dioicum videtur (floribus masculis ignotis). *Plate XVI.*

California: on ground in old pastures, foothills near Stanford University (C. F. Baker, 1902).

Var. **elongatum** Card. & Thér., var. nova.—A forma typica differt caulibus altioribus foliisque superioribus longioribus et magis flexuosis.

California: on wet clay soil, foothills near Palo Alto (C. F. Baker, 1902).

Distinguished from *P. subulatum* Br. Eur. by the shorter and less finely subulate leaves, with a broader costa. The latter character also separates our species from *P. Bolanderi* C. Müll., which, besides, has the leaves distinctly denticulate on the margins from the middle upward. *P. Ravenelii* Aust., of which we have seen no authentic specimen, according to the description has carinate leaves, excurrent costa, and synoicous inflorescence. If the inflorescence of *P. Bakeri* is, as we think, really dioicous, this character would distinguish it from all the other North American and European species of Pleuridium.

DICRANELLA CURVATA Sch. var. **missourica** Card. & Thér., var. nova.—A forma typica differt capsula minus distincte striata et areolatione foliorum e cellulis latioribus brevioribusque composita.

Missouri: Seligman, on ground (B. F. Bush, 1898).

Dicranum alatum (Barnes) Card. & Thér., sp. nova. (*D. Bonjeani* de Not. var. *alatum* Barnes, Bot. Centralbl. **44**: 386. 1890). —Atroviride, dense cespitosum, intus tomentosum, 4–6^{cm} altum. Folia falcato-secunda, 3–5^{mm} longa, 1^{mm} lata, lanceolata, acuta, superne carinata, haud vel vix undulata, in tertia parte superiore acute dentata, dentibus in foliis superioribus longioribus et magis numerosis, costa basi 120μ, medio circa 100μ lata, in dimidio superiore dorso duabus alis altis dentatis ornata, cellulis inferioribus rectangulis, hyalinis, haud porosis, mediis 40–50μ longis, 12–15μ latis, valde porosis, superioribus brevioribus latioribusque, 30–36μ longis, 18μ latis, valde chlorophyllosis, alaribus

breviter rectangulis, inflatis, lutescentibus. Caetera ignota. *Plate XVII.*

Illinois: Chicago (Dr. J. Röll, 1888). Wisconsin: Madison (Cheney and True). W. Minnesota: Cedar Lake, near Montevideo, Chippewa county (J. M. Holzinger, 1901).

The nerve bearing on the back two high, serrate lamellae, and the shorter, thinner-walled cells of the areolation, seem characters of sufficient value to separate this moss from *D. Bonjeani*.

Fissidens Bushii (Card. & Thér.) Card. & Thér. sp. nova. (*F. subbasilaris* var. *Bushii* Card. & Thér. in BOT. GAZETTE **30**: 16. 1900).—Monoicus, laxe cespitosus, pallide vel lutescenti-viridis. Caulis brevis, 5–8^{mm} longus, divisus. Folia oblongo-lanceolata, obtusa, abrupte apiculata, toto ambitu minute denticulata, 1.2–1.4^{mm} longa, 0.45^{mm} lata, lamina dorsali basi rotundata, haud undulata, costa percurrente, basi 40μ crassa, rete opaco e cellulis minutis, angulosis subrotundatisve, 6–7μ latis, parietibus incrassatis, marginalibus haud vel parum translucentibus. Flores feminei in ramulis brevibus basalibus. Caetera ignota. *Plate XVII.*

Missouri: Eagle Rock, on gravelly ground (B. F. Bush, 1897). Texas (Elsa Baumann; herb. Dr. Zickendrath).

At first we considered this moss as a variety of *F. subbasilaris* Hedw., but further observations led us to a different conclusion, and now we think it preferable, on account of the inflorescence and the costa reaching the apex, to place it near *F. taxifolius* Hedw., of which it may be a subspecies, characterized by the nearly twice smaller size, the obtuse abruptly apiculate leaves with the dorsal wing not undulate at base and with smaller cells. From *F. subbasilaris* it is easily distinguished by the inflorescence and the costa reaching the apex.

FISSIDENS PUSILLUS Wils. var. **brevifolius** Card. & Thér., var. nova.—A forma typica differt foliis innovationum sterilium multo brevioribus, magis abrupte et brevius acuminatis.

California: Soldier's Home, Los Angeles county (Dr. Hasse, 1902; herb. C. F. Baker).

Pottia nevadensis Card & Thér., sp. nova.—Monoica? viridis, densiuscule cespitosa. Caulis erectus, brevis, 1–2^{mm} altus. Folia erecta, ovata, concava, media 1^{mm} longa, 0.6^{mm} lata, inferiora minora, omnia laevia, marginibus integris, saltem uno latere parce

revolutis, costa angusta, in cuspidem subpiliformem abrupte excurrente, cellulis mediis hexagonis rhomboidalibusve, parce chlorophyllosis, circa 18 μ longis, 15 μ latis, superioribus paululum minoribus, basilaribus elongato-rectangulis, 40 μ longis, 18 μ latis, omnibus perfecte laevibus. Folia perichaetialia multo majora et latiora, valde concava, usque 2 mm longa. Capsula in pedicello pallido, flexuoso, 10–15 mm longo, erecta, oblonga, basi attenuata, ore truncata, pallida, gymnostoma, 1.5–2 mm longa, 0.75 mm crassa, operculo depresso, longe tenuirostro, 1.2 mm longo, columellae parum adhaerente. Sporae dense papillosae, 24–30 μ crassae. *Plate XVIII.*

Nevada: Kings Cañon, near Carson, on ground about willow thickets (C. F. Baker, 1902).

This species seems very distinct from any other European or North American Pottia.

DIDYMODON TOPHACEUS Jur. var. **decurrens** Card & Thér., var. nova.—Var. *elatae* similis. Folia remota, madida recurva, longe decurrentia, dorso valde papillosa, costa scabra.

Texas: Shovel Mt., Burnet county (Rev. Franciscus Ebeling; herb. Dr. E. Zickendrath).

Desmatodon Bushii Card & Thér., sp. nova.—Laxiuscule cespitosus, olivaceo-viridis. Caulis erectus, 5–15 mm altus, simplex vel divisus. Folia sicca crispatula, madida erecto-patentia, 1–1.5 mm longa, 0.4 mm lata, oblongo-lanceolata, plerumque obtusa, costa breviter excurrente mucronata, marginibus integris longe revolutis, cellulis inferioribus rectangulis, hyalinis vel paululum lutescentibus, 35–40 μ longis, 9 μ latis, caeteris quadrato-rotundatis, valde papillosis, opacis, diam. 7–8 μ, costa basi 60 μ crassa. Folia perichaetialia majora, in tertia vel dimidia parte inferiore hyalina, magis acuminata, marginibus tantum superne revolutis. Capsula in pedicello pallide rubello, circa 10 mm longo, erecta, subcylindrica, cum operculo 2 mm longa, 0.44 mm crassa, operculo conico, breviusculo, 0.5 mm longo. Calyptra dimidiam partem capsulae obtegens. Peristomium 0.35 mm altum, purpureum, membrana basilari brevi, dentibus leniter contortis, usque ad basin in 2 crura filiformia, papillosa, saepissime inferne 2 vel 3 trabeculis coalita divisis. Sporae laeves, variabiles, globulosae vel

ellipticae, diam. 20–30 μ. Dioicum videtur (floribus masculis ignotis). *Plate XVII.*

Missouri: Courtney, on wet rocks (B. F. Bush, 1898).

Much resembling *Barbula unguiculata* Hedw. by the habit and the shape and areolation of the leaves, but readily distinguished from it by the peculiar structure of the peristome, which is hardly twisted, and by the spores twice larger. C. Müller described a *B. cancellata*, the peristome of which according to the description must have a similar structure to that of our *D. Bushii*, but the teeth are smooth (likely twisted), and the lid is as long as the capsule.

DESMATODON SYSTILIOIDES Ren. & Card., BOT. GAZETTE **30**:16. 1900 is not a *Desmatodon* but a new *Pottia* of the group *Heimii*.

Barbula macrotricha Card & Thér., sp. nova.— Pulvini compacti, superne grisei. Caulis brevissimus, 1–2 ^{mm} altus. Folia madida erecta, gemmatim conferta, sicca contortula, 1–1.5 ^{mm} longa, 0.6–0.8 ^{mm} lata, ovata vel breviter subspathulata, apice late obtuso, praecipue in foliis inferioribus saepe emarginato, aetate eroso, marginibus integerrimis, basi planis, deinde usque apicem versus revolutis, costa angusta, 4–8 μ crassa, in pilo laevi, hyalino, in foliis inferioribus brevi, in superioribus limbo aequilongo, imo longiore excurrente, cellulis inferioribus quadratis vel breviter rectangulis, 18 μ latis, hyalinis vel vix chlorophyllosis, sublaevibus, caeteris minoribus, circa 12 μ latis, quadratis subrotundatisve, valde chlorophyllosis et grosse papillosis inde obscuris, indistinctis. Capsula in pedicello basi rubello, superne pallidiore, brevi, 6–8 ^{mm} longo, erecta, subcylindrica, curvatula, unacum operculo conico-elongato 2.5 ^{mm} longa. Ob capsulas immaturas caetera ignota. Dioica videtur (floribus masculis in planta fructifera non visis). *Plate XVIII.*

California: Soldier's Home, Los Angeles county (Dr. Hasse, 1902; herb. C. F. Baker).

In general appearance resembling the smallest forms of *B. muralis* Timm., from which it differs by the smaller size, the short pedicel, the much shorter leaves obtuse or emarginate and finally eroded at the apex, the hair of the upper leaves as long as or even longer than the lamina, etc.

Barbula Bakeri Card & Thér., sp. nova.— Dioica, laxiuscule cespitosa, olivaceo- vel lurido-viridis, 3–8 ^{mm} alta. Folia sicca erecta, contortula vel crispatula, madida patulo-squarrosa, 1.4–1.5 ^{mm} longa, 0.6–0.7 ^{mm} lata, e basi ovata longiuscule acuminata,

carinata, marginibus integris e basi usque apicem versus valde revolutis, costa percurrente, basi 60 μ crassa, rete laevi vel vix papilloso, cellulis subuniformibus, quadrato-rotundatis, 6 μ latis, nonnullis ad basin folii juxta costam breviter rectangulis, 9 μ longis. Folia perichaetialia caulinis subsimilia, tamen paululum, longius acuminata. Capsula in pedicello rubello, circa 10^{mm} longo, erecta, oblonga subcylindricave, unacum operculo conico-rostrato 2.5–3^{mm} longa. Calyptra dimidiam partem capsulae obtegens. Annulus distinctus, persistens. Peristomium purpureum, 0.6^{mm} altum, dentibus semicontortis. Sporae laeves, pallidae, diam. 8–9 μ. *Plate XVIII.*

California: Stanford University, on stones bordering flower beds (C. F. Baker, 1901); foothills near Palo Alto, on ground (C. F. Baker, 1902); Alma, Santa Clara county, on bowlder (C. F. Baker, 1902); Soldier's Home, Los Angeles county (Dr. Hasse, 1902; herb. C. F. Baker).

A species belonging to the perplexing group of *B. fallax* Hedw., differing from this species by its smooth or very slightly papillose leaves with margins more broadly revolute, and by its shorter, slightly twisted peristome. From *B. virescens* Lesq. it is distinguishable by its shorter leaves, broader at base, its almost uniform areolation, and its lower cells small, quadrate, chlorophyllose, with thinner walls.

BARBULA HUMILIS Hedw., Sp. Musc. 116, tab. XXV, *figs. 1–4.*

Missouri: Swan, on rocks (B. F. Bush, 1899).

A reduced form of *B. caespitosa* Schw. (See: Cardot, Revision des types d'Hedwig et de Schwaegrichen, in Bull. Herb. Boiss. 7: 304. 1899).

Grimmia cognata Card. & Thér., sp. nova.—Verisimiliter dioica, densiuscules cespitosa, superne lutescenti-viridis, inferne fusca. Caulis pro more basi longe denudatus, ascendens arcuatusve, parce ramosus, 2–5^{cm} longus. Folia sicca erecto-flexuosa, madida erecto-patentia, 2.5–3.5^{mm} longa, 0.7^{mm} lata, lanceolata, sensim et longe acuminata, carinata, pilo hyalino integro praedita, marginibus uno latere parce revolutis, rete opaco, cellulis inferioribus linearibus, 30–40 μ longis, 6–8 μ latis, parietibus valde incrassatis et sinuosis, caeteris quadrato-rotundatis vel breviter rectangulis, in dimidio superiore bistratosis. Caetera ignota. *Plate XIX.*

Colorado: along the Cogwheel Railway to Pike's Peak, alt. 2100–3000^{m} (J. M. Holzinger, 1896).

Closely allied to *G. trichophylla* Grev., of which it may be considered as a subspecies; differing from it in its more robust size, recalling that of *G. elatior* Br. Eur., its stems naked below, and the basal areolation with much thicker and more sinuate walls.

GRIMMIA HENDERSONI Ren. & Card., Rev. Bryol. **19**: 86. 1892. —A *G. decipienti* Lindb. proxima differt caulibus brevioribus, 10–15^{mm} altis, foliis minoribus, 2.5^{mm} longis, 0.8^{mm} latis, costa angustiore, 65μ basi crassa, cellulis mediis minoribus, 6–8μ latis, inferioribus laxioribus, 24–35μ longis, 10–14μ latis, pedicello breviore, 4–5^{mm} longo, capsula angustiore, subcylindrica, 1.6^{mm} longa, 0.7^{mm} crassa, minus profunde sulcata, operculo longius rostrato, 1^{mm} longo, peristomii dentibus minus profunde fissis, 0.36^{mm} altis, denique sporis laevibus, multo minoribus, 9μ crassis. *Plate XX.*

Oregon: sunny dry rocks in rill bed, Hood River (L. F. Henderson, 1889).

BARTRAMIA ITHYPHYLLA Brid. var. **fragilifolia** Card. & Thér., var. nova.—A forma typica differt foliis rigidis, fragilibus, plerumque effractis.

Colorado: along the Cogwheel Railway to Pike's Peak, 2100–3000^{m} alt. (J. M. Holzinger, 1896).

By its brittle and usually broken leaves, this form much resembles *B. breviseta* Lindb.; but in the latter the leaf base is hardly glossy and less abruptly contracted to the subula.

Webera chlorocarpa Card. & Thér., sp. nova.—Densiuscule cespitosa, basi terra obruta, inferne fusco-viridis, superne lutescens. Caulis 1–2^{cm} altus, erectus, simplex divisusve. Folia erecto-appressa, 2^{mm} longa, 1^{mm} lata, ovato-lanceolata, acute acuminata, basi paulo decurrente, marginibus planis integris, costa inferne 80μ crassa breviter excurrente, cellulis basilaribus quadratis vel breviter rectangulis, subinflatis, 40–60μ longis, 25–40μ latis, mediis hexagono-rhomboidalibus, 40μ longis, 18–20μ latis, marginalibus e tertia parte inferiore angustis, lincaribus, 4–5-seriatis quemdam limbum lutescentem subefformantibus. Capsula in pedicello rubello, superne pallido, plus minus flexuoso, 2–2.5^{cm} longo, nutans vel pendula, ovato-pyriformis, collo sporangio aequilongo attenuata, pallide flavescens, aetate plicata, sub ore haud constricta, parietibus mollibus, sto-

matibus numerosis, emersis, 2–2.5^{mm} longa, 0.75^{mm} crassa, operculo convexo, obtuse apiculato. Annulus latus. Exostomii dentes 0.44^{mm} alti, 20–25 lamellis praediti; endostomii membrana praealta, ultra medium dentium producta, processus in carina late hiantes, cilia solitaria vel bina, plus minus elongata, ut processus subtiliter granulosa. Sporae 18–20μ crassae. Dioica videtur (floribus masculis in planta fructifera non visis). *Plate XX.*

Nevada: Marlette Lake, Washoe county, on stream bank (C. F. Baker, 1902).

Resembles in habit *W. gracilis* De Not., but much stronger, with a very different areolation of broad and short cells. The leaf areolation recalls that of the genus *Mniobryum* Limpr., but the stomata of the capsule are superficial and the annulus is quite distinct.

Webera Debati Card. & Thér., sp. nova.—Laxe cespitosa, lutescenti-viridis, habitu philonotideo. Caulis 1.5–2.5^{cm} altus, inferne dense radiculosus, inde tomentosus, innovationibus gracilibus erectis. Folia inferiora sat remota, erecto-patentia, superiora magis conferta, appressa, circa 1.3^{mm} longa, 0.33^{mm} lata, lanceolata, acuta, basi haud decurrentia, marginibus planis toto fere ambitu denticulatis, costa basi 40μ crassa, sub summo apice evanida, cellulis mediis linearibus, 140–170μ longis, 28–30μ latis, inferioribus latioribus brevioribusque, rectangulis vel subhexagonis, marginalibus longioribus, anguste linearibus. Caetera ignota. *Plate XX.*

N. America: Alexander county (Herb. L. Debat, without name of collector.)

This species seems closely connected with *W. annotina* Bruch, from which it is distinguished by the larger size, the habit resembling that of a small Philonotis, the tomentose stems and the leaves plane on the margins.

Bryum pendulum Sch. var. **nevadense** Card. & Thér., var. nova.—A forma typica differt capsula angustiore, illae varietatis *angustatum* Ren. simili sed majore, operculo convexo-apiculato, haud conico, denique foliis costaque basi viridibus, nec rubentibus.

Nevada: King's Cañon, near Carson, along stream (C. F. Baker, 1902).

Bryum polycladum Card. & Thér., sp. nova.—Synoicum dense lateque cespitosum, intus fuscum, superne laete viride. Caulis

brevis, 3–5^{mm} altus, ramis gracilibus, erectis, numerosis, sub perichaetio nascentibus. Folia erecto-appressa, conferta, inferiora brevia, 1^{mm} longa, 0.5^{mm} lata, media superioraque paulo majora, 1.5^{mm} longa, 0.5–0.6^{mm} lata, basi haud decurrentia, ovata vel ovato-oblonga, breviter acuminata, marginibus e basi usque apicem versus anguste revolutis, superne denticulatis, costa valida, rubente, basi 60–65μ crassa, in foliis mediis et superioribus brevissime excurrente, in inferioribus apicem vix excedente, cellulis mediis et superioribus breviter subhexagonis, 30–35μ longis, 12μ latis, parietibus incrassatis, marginalibus linearibus, 2–3-seriatis, inferioribus majoribus, laxioribus, rectangulis, 35–50μ longis, 12–18μ latis. Capsula in pedicello rubello flexuoso, elongato, 4–6^{cm} alto, nutans vel pendula, oblonga, 4–4.5^{mm} longa, 1–1.2^{mm} crassa, collo madore in pedicello abrupte contracto, operculo convexo-apiculato. Annulus latus. Exostomii dentes angusti, pallidi, inferne rubelli, 18–22 lamellis instructi, 0.35–0.4^{mm} alti, basi 50μ lati. Endostomium exostomio adhaerens, membrana ad $\frac{1}{3}$ dentium producta, processibus linearibus, in carina fissis, ciliis brevissimis obsoletisve. Sporae minutae, pallidae, diam. 12μ. *Plate XXI.*

Nevada: Spooner, Douglas county, in large mats on moist banks (C. F. Baker, 1902).

This moss can be placed near *B. longisetum* Bland., but it is easily distinguished from it by the numerous sterile branches arising from below the perichaetium, the smaller leaves with a shorter acumen, the peristomial teeth, which are narrower and paler, and have more numerous lamellae, and finally the much smaller spores.

Bryum anceps Card. & Thér., sp. nova.—Dense cespitosum, lutescenti-viride. Caulis simplex vel parce ramosus, 5–10^{mm} altus, interrupte foliosus. Folia ad apicem innovationum in comam congesta, circa 1.5^{mm} longa, 0.8^{mm} lata, concava, e basi paulo decurrente late ovata, brevissime acuminata, inferiora mediaque obtusa, superiora subobtusa vel subacuta, apice integro subdenticulatove, marginibus saltem uno latere in dimidio superiore revolutis, costa valida, basi dilatata, 100μ crassa, sensim attenuata et sub apice evanida, rete perlaxo, cellulis inferioribus quadratis vel rectangulis, caeteris hexagonis, circiter 50μ longis,

20 μ latis, omnibus parietibus mollibus, angustis. Caetera ignota. *Plate XIX.*

N. W. Montana: in the vicinity of Lake MacDonald, Flathead county, 1000–2100^{m} alt. (J. M. Holzinger and J. B. Blake, 1898).

The relationship of this moss is rather doubtful; it seems, however, to have some affinity with *B. capitellatum* C. Müll. & Kindb., which it resembles in habit and form of the leaves, but it has more slender stems, the leaves somewhat decurrent, revolute in the lower part at least on one side, a looser areolation formed of much wider and softer cells with thinner walls, and a much broader nerve (100 μ wide at base, instead of 60), ending at a little distance below the apex.

BRYUM SANGUILENTUM Ren. & Card. Rev. Bryol. **20**: 31. 1893; Bull. Herb. Boissier **4**: 17. 1896. (*B. occidentale* var. Sulliv. & Lesq. Musci Bor.-Amer. exsicc., ed. 2, nos. 283 and 284).—Dioicum, dense cespitosum, superne viride, inferne fuscum. Caulis 10–15^{mm} altus, radiculosus, innovationibus gracilibus. Folia conferta, madida erecto-imbricata, concava, sicca plus minus flexuosa, haud vel vix spiraliter torta, circa 3^{mm} longa et 1^{mm} lata, subspathulato-oblonga, marginibus integris vel apice minute denticulatis, e basi longe revolutis, superne planis, costa basi 90 μ crassa, sensim angustata, longiuscule et tenuiter excurrente, rete laxo, cellulis basilaribus rectangulis, 60–120 μ longis, 24–30 μ latis, mediis hexagonis rhomboidalibusve, 40–50 μ longis, 15 μ latis, superioribus brevioribus, marginalibus 1–2-seriatis, angustioribus, limbum parum distinctum saepe subnullum efformantibus. Capsula in pedicello pallide rubello, flexuoso, 1.5–3^{cm} longo, nutans pendulave, anguste subcylindrica, basi attenuata, arcuatula, 5^{mm} longa, 0.9^{mm} crassa, matura in dimidio superiore plerumque sanguinea, basin versus pallidiore, operculo nitido, convexo. Annulus latus, triplex. Endostomii membrana elata, usque ad $\frac{2}{3}$ dentium producta, ciliis appendiculatis. Sporae laeves, diam. 12–15 μ. *Plate XXIII.*

California: "in truncis emortuis et deustis Californiae (Bigelow et Bolander comm.)." Sulliv. et Lesq. Musci Bor.-Amer. Exsicc. ed. 2, no. 284, as *B. occidentale* var.; Mill Valley, Marin county, on old stumps of *Sequoia sempervirens* (Marshall A. Howe, 1892 and 1894; Ren. & Card. Musci Amer. Sept. Exsicc. no 223); Sonoma county (Miss Martha R. Mann, 1886); foothills near Palo Alto, on old logs (C. F. Baker, 1902). We have a specimen from Sonoma county labeled "*Bryum arenarium* Hpe.," sent by the Königl. Bot. Museum in Berlin.

Differs from the small forms of *B. capillare* L. by its capsule generally narrower, light red in the upper part when ripe, and by the less distinct border of its leaves. *B. torquescens* Br. Eur. is a more robust plant, with the leaves generally strongly twisted when dry, distinctly bordered, and a synoicous inflorescence.

Bryum brevicuspis Card. & Thér., sp. nova.—Synoicum, dense cespitosum lurido-viride. Caulis 1–2^{cm} altus, radiculosus, sub perichaetio innovans. Folia madida erecto-patentia, sicca spiraliter contorta, circiter 1.5^{mm} longa et 0.65^{mm} lata, ovato oblonga, breviter acuminata, marginibus e basi usque apicem versus revolutis, superne denticulatis, costa inferne rubella, 72–82μ crassa, percurrente vel saepius brevissime excurrente, cellulis mediis hexagonis vel rhomboidalibus, 30–35μ longis, 12μ latis, valde chlorophyllosis, parietibus angustis, superioribus longioribus, inferioribus majoribus, laxioribus, breviter rectangulis, hyalinis, marginalibus angustis, 2–3-seriatis, limbum sat distinctum efformantibus. Capsula in pedicello flexuoso, circa 1.5^{cm} longo, pendula, brevis, matura et sicca sub ore paulo constricta, 1.6^{mm} longa, 0.9^{mm} crassa, operculo convexo-apiculato. Peristomium perfectum, ciliis appendiculatis. Sporae laeves, diam. 13–15μ. *Plate XXII.*

Missouri: Eagle Rock, on tree (B. F. Bush, 1898).

Easily distinguished from *B. capillare* L. by its synoicous flowers, very briefly excurrent costa and shorter capsule. Differs from *B. provinciale* Philib. by its smaller leaves, more narrowly revolute, with a shorter point, not so much denticulate in the upper part, and also by its shorter capsule. It seems more closely connected with *B. oreganum* Sulliv.; but from Sullivant's description and drawings (Exped. Wilkes, Musci, 10, *pl.* 7, B) the latter has shorter stems, more serrate leaves, not twisted when dry, and a longer capsule.

Bryum distantifolium Card. & Thér., sp. nova.—Cespites molli, luridi, circa 5^{cm} alti. Caulis erectus, parce radiculosus, simplex vel superne 3–5 innovationes graciles emittens. Folia dimorpha, omnia integra, anguste sed distincte decurrentia, marginibus planis vel basi tantum subrevolutis: inferiora remota, parva, breviter acuminata, saepe obtusa subobtusave, 0.9^{mm} longa, 0.5^{mm} lata, limbo nullo vel indistincto, costa haud excurrente; media superioraque minus remota, majora, 2–2.4^{mm} longa et 0.9^{mm} lata, lanceolata, longe acuminata, costa basi 70μ crassa in cuspidem

rubentem breviter excurrente, cellulis mediis rectangulis, 60–80 μ longis, 15 μ latis, marginalibus 2–3-seriatis angustis, linearibus, limbum distinctum efformantibus. Caetera ignota. *Plate XXI.*

Assiniboia: Wood Mountains (Macoun, 1895. Sent as *B. erythrophylloides* Kindb.).

Somewhat recalling the slender forms of *B. pallens* Sw., but differing by its dimorphous leaves, which are plane on the margins or nearly so. The leaves decurrent at base, the upper distinctly limbate, at once distinguish this moss from Kindberg's *B. erythrophyllum* and *B. erythrophylloides*.

Bryum subdrepanocarpum Card. & Thér., sp. nova.—Dioicum, laxe cespitosum, viride. Caulis brevis, 5–7^{mm} altus, inferne radiculosus, sub perichaetio innovans, innovationibus gracilibus, laxe foliosis. Folia inferiora remota, superiora in rosulam congesta, 1–1.5^{mm} longa, 0.6–0.75^{mm} lata, ovato-oblonga, breviter acuminata, marginibus longe revolutis, superne planis et denticulatis, costa basi 80 μ crassa, pro more infra apicem evanida, rete laxo, cellulis basilaribus rectangulis, mediis superioribusque oblongo-hexagonis, 60 μ longis, 18–20 μ latis, marginalibus angustis, linearibus, lutescentibus, 1–2-seriatis. Capsula in pedicello inferne rubello, superne pallido, 1.5–2^{cm} longo, pendula vel nutans, oblonga, arcuata, longicollis, operculo convexo-apiculato. Annulus latus. Peristomium perfectum, ciliis appendiculatis. Sporae 8–12 μ crassae. *Plate XXII.*

California: Soldier's Home, Los Angeles county (Dr. Hasse, 1902; herb. C. F. Baker).

This moss is very near *B. drepanocarpum* Philib., from which it differs by its shorter and broader leaves, denticulate in the upper part, and forming a small rosette or bud at the top of each stem, and by its costa generally vanishing below the apex.

Bryum camptocarpum Card. & Thér., sp. nova.—Monoicum, laxiuscule cespitosum, lutescenti-viride. Caulis brevis, circa 5^{mm} altus, radiculosus, simplex ramosusve. Folia erecta, sat conferta, oblongo-lanceolata, acuminata, media superioraque 2^{mm} longa, 0.6–0.7^{mm} lata, inferiora breviora, marginibus incrassatis, planis vel inferne vix reflexis, apicem versus subdenticulatis, costa rubente, basi 80–90 μ crassa, in foliis inferioribus breviter, in superioribus longius excurrente, cellulis mediis superioribusque hexagonis rhomboidalibusque, 54–70 μ longis, 18–24 μ latis, basi-

laribus rectangulis, 80–90μ longis, 25–30μ latis, marginalibus linearibus, limbum pulchre distinctum lutescentem, incrassatum, 2–3-stratosum efformantibus. Flos masculus in ramo proprio terminalis. Capsula in pedicello rubello, 1.5–3^{cm} longo, nutans, oblonga, arcuata, 4–4.5^{mm} longa, 1^{mm} crassa, collo attenuato sporangio aequilongo, operculo convexo, breviter apiculato. Annulus duplex et triplex. Peristomium perfectum, 0.48^{mm} altum; endostomii membrana ultra medium dentium producta, processus in carina anguste et parce fissi, cilia 1–3, appendiculata. Sporae papillosae, diam. 24μ. *Plate XXII.*

Newfoundland: John's Beach, wet places (Rev. Arthur C. Waghorne, 1895).

Allied to *B. meeseoides* Kindb., *B. drepanocarpum* Philib., and *B. subdrepanocarpum* Card. & Thér. by the form of the capsule, but distinct from these species by the monoicous inflorescence and by the leaves plane on the margins, or nearly so, with a very distinct and thickened border. It also much resembles *B. pallens* Sw. var. *arcuatum* Sch., from which, however, it differs by the shorter leaves, with margins plane or scarcely reflexed at base and denticulate or sinuate at apex.

Bryum dimorphophyllum Card. & Thér., sp. nova.—Verisimiliter dioicum, sat robustum. Cespites compacti, cohaerentes, superne lutescenti-virides, intus dense rufo-tomentosi. Caulis erectus, 4–5^{cm} altus, pluries divisus. Folia sicca erecta, ramea contorta, madida erecto-patentia, dimorpha: inferiora valde concava, e basi longe decurrente ovata vel oblonga, 1.5^{mm} longa, 1^{mm} lata, apice cucullato obtusissimo, costa sub apice evanida, superiora majora et angustiora, 2.2^{mm} longa, 0.8^{mm} lata, lanceolata, acuminata, acuta, minus decurrentia, costa percurrente vel breviter excurrente; omnia marginibus integris, e basi usque apicem versus revolutis, cellulis quadratis, breviter rectangulis vel rhomboidalibus, 30μ longis, 14μ latis, parce chlorophyllosis, parietibus crassis, marginalibus angustioribus, linearibus. Folia perichaetialia minora, angustiora, acuta, costa breviter excurrente. Capsula in pedicello purpurascente circa 2^{cm} longo nutans pendulave, anguste subpyriformis, 3^{mm} longa, 0.9^{mm} crassa, sicca et matura sub orificio paulisper constricta, operculo convexo-conico. Annulus latus, triplex. Endostomii membrana elata, ciliis 2–3, appendiculatis. Sporae laeves, inaequales, aliae, magis numer-

osae, minores, diam. 11 μ, aliae, rariores, majores, diam. 18 μ. Planta mascula ignota. *Plate XIX.*

N. W. Montana: Mt. Lottie Stanton and Mt. Trilby, in the vicinity of Lake MacDonald, Flathead county, 1100–1800^{m} alt. (J. M. Holzinger and J. B. Blake, 1898).

Belongs to the group of *B. pseudotriquetrum* Schw., but is at first sight distinguished from all the other species of this group by its dimorphous leaves.

AULACOMNIUM PALUSTRE Schw. var. **dimorphum** Card. & Thér., var. nova.—Caulis superne innovationibus numerosis ramosissimus. Folia dimorpha, caulina elongata, acute acuminata, apice sinuato-subdenticulata, valde papillosa, ramea multo breviora, obtusa, integerrima, minus papillosa, interdum laevia.

Colorado: near Breckenridge, 175^{km} from Denver, alt. 3000^{m} (J. M. Holzinger, 1896).

A similar form is recorded by Mr. Dixon in his admirable *Handbook of British Mosses* 282.

AULACOMNIUM PALUSTRE Schw. var. **lingulatum** Card. & Thér, var. nova.—Gracile, formis majoribus *A. androgyni* simile. Folia lingulata, omnia obtusa, integra apiceve sinuolata.

Colorado: bog near Chamber's Lake (C. S. Crandall, 1894; herb. J. M. Holzinger).

Distinguished from the var. *imbricatum* Br. Eur. by its smaller size and its longer, not imbricated leaves.

Fontinalis subcarinata Card., sp. nova.—Mollis, lutescenti vel lurido-viridis. Caulis 15–20^{cm} longus, inferne denudatus, ramis elongatis, gracilibus, erectis, attenuatis, subcuspidatis. Folia mollia, quadrifaria, erecta, 4–5^{mm} longa, 1–2^{mm} lata, anguste lanceolata, longe acuminata, integerrima apiceve subdenticulata, plerumque sulco longitudinali medio distincte notata, lateralia subconduplicata, cellulis angustissimis longissimisque, alaribus paucis, parvis, parum distinctis, saepe subnullis. Caetera ignota. *Plate XXIII.*

Assiniboia: Cypress Hills, Battle Creek (Macoun, 1895. Sent as *F. Lescurii*).

This species belongs to the sect. MALACOPHYLLAE, and is closely allied to *F. seriata* Lindb., but differs from it by its plicate leaves, with less distinct alar cells.

FONTINALIS OBSCURA Card. Minn. Bot. Stud. **3**: 120. 1903.—In the note following the description of this species, the phrase: "It belongs to the section HETEROPHYLLAE" should be stricken out.

CLIMACIUM AMERICANUM Brid. var. **pseudo-Kindbergii** Card. & Thér., var. nova.—Habitu *C. Kindbergii* omnino simile, sed areolatione cum *C. americano* exacte congruit.

Missouri: Paw Paw Junction, on old log; Pleasant Grove, on wet bank (C. F. Bush, 1897 and 1899).

Contrary to the opinion of Dr. A. J. Grout, we think that *C. Kindbergii* cannot be distinguished specifically from *C. americanum*. We have specimens on which the distinctive characters become attenuated. The plant of which we make the var. *pseudo-Kindbergii* is just one of these forms.

LESCURAEA STRIATA Br. Eur. fasc. 46–47.

Labrador: Lack Harbour, on rocks (Rev. Arthur C. Waghorne).

This specimen, sent by Waghorne as *L. saxicola* Milde seems to us nearer to *L. striata*, on account of its leaves less imbricate and not homomallous; yet it differs from the European type by the shorter acumen of the leaves, distinctly denticulate towards the apex. *Pseudoleskea substriata* Best has much smaller leaves, but is also merely a form of *L. striata*.

Brachythecium subasperrimum Card. & Thér., sp. nova.—Laxe intricato-cespitosum, lutescenti-viride, nitidulum. Caulis gracilis, 3–6^{cm} longus, prostratus, radicosus, ramis inaequalibus attenuatis, ascendentibus irregulariter pinnatus. Folia caulina erecto-patentia, e basi decurrente deltoidea, sensim longe et anguste acuminata, vix plicatula, sublaevia, 1.8–2^{mm} longa, 0.75^{mm} lata, marginibus basi leniter reflexis, subintegris vel inferne parce denticulatis, costa angusta, 36μ basi crassa, medium versus evanida, cellulis mediis linearibus, angustis, 60–85μ longis, 6μ latis, basilaribus laxioribus, hyalinis, rectangulis vel subhexagonis; folia ramea oblonga, longe et anguste acuminata, nec deltoidea, nec decurrentia, distinctius plicatula, 1.6^{mm} longa, 0.5^{mm} lata, marginibus plus minus longe revolutis, superne minute denticulatis. Folia perichaetialia enervia, e basi ovata amplexicauli in acumen patulum vel reflexum, angustum, elongatum, integrum abrupte constricta. Capsula in pedicello purpureo scaberrimo, papillis altis dense obtecto, 1.5^{cm} longo, inclinata vel subhorizontalis, ovata, gibbosa, sicca sub ore leniter constricta, 1.7^{mm} longa,

0.8 mm crassa, operculo ignoto. Peristomium perfectum, ciliis appendiculatis. Sporae 15 μ crassae. Dioicum videtur (floribus masculis ignotis). *Plate XXIV.*

British Columbia: New Westminster (A. J. Hill, 1902; herb. C. F. Baker).

By the habit, dioicous inflorescence and very rough pedicel this moss stands near *B. asperrimum* (Mitt.) Kindb. and *B. Washingtonianum* Eaton, differing from both in having the leaves scarcely plicate, almost smooth, with the acumen much longer and narrower, and the borders very slightly denticulate or subentire and partly revolute.

Plagiothecium sulcatum Card. & Thér., sp. nova.—Monoicum, laxiuscule depresso-cespitosum, nitidulum. Caulis gracilis, repens, ramis ascendentibus, subarcuatis, circa 1 cm longis, compressulis. Folia ramea laxe subdisticho-homomalla, 1.2–1.5 mm longa, 0.4–0.5 mm lata, haud decurrentia, lanceolata, sensim longe acuminata, marginibus planis, e medio, nonnunquam e basi serrulatis, costa gemella, nunc brevi, nunc longiore et uno crure fere ad medium producta, cellulis anguste linearibus, 70–90 μ longis, 6 μ latis, inferioribus brevioribus, laxioribus, non porosis, 20–40 μ longis, 12–15 μ latis. Flores masculi prope femineos nascentes. Folia perichaetialia erecta, appressa, enervia, breviter ovata, apice rotundata, apiculo erecto brevi abrupto. Capsula in pedicello pallide purpurascente, tenui, flexuoso, 2 cm longo, subhorizontalis inclinatave, 2 mm longa, 0.7 mm crassa, subcylindrico-arcuata, vacua infra orificium contractula, tam juvenilis quam matura profunde sulcata, operculo obtuse conico. Annulus duplex. Peristomium perfectum, 0.42 mm altum, ciliis nodulosis, minute papillosis. Sporae laeves, diam. 12 μ. *Plate XXIV.*

N. Minnesota: on Fall Lake, near the foot of Kawasatchong Falls, 11 km north of Ely (J. M. Holzinger, 1897. Sent as *P. Muehlenbeckii* Br. Eur.).

This moss seems somewhat intermediate between *P. striatellum* Lindb. (*P. Muehlenbeckii* Br. Eur.) and *P. silesiacum* Br. Eur., differing from the former by its non-decurrent leaves, narrower at base, with a more distinct costa, its much longer cells, the basilar ones not porose, its more arcuate capsule, and the form of its perichaetial bracts; and from the latter by its capsule being deeply sulcate, even when young, and its more compressed branches. According to the description, *P. pseudosilesiacum* Sch. differs from our species by its much shorter pedicel (1 cm), and its ecostate leaves.

Plagiothecium Groutii Card. & Thér., sp. nova.—Monoicum, tenellum, nitidum, densiuscule depresso-cespitosum. Caulis tenuis, prostratus, ramis brevibus numerosis complanatis. Folia minuta, compressa, distiche erecto-patentia, 0.7–0.8^{mm} longa, 0.3–0.35^{mm} lata, haud decurrentia, oblongo-lanceolata, lateralia subcultriformia, breviter et latiuscule acuminata, margine plana, enervia, caulina subintegra vel obsolete denticulata, ramea in tertia parte superiore vel fere e medio minute sed distincte serrulata, cellulis mediis linearibus, angustissimis, 60–90μ longis, 6μ latis, superioribus brevioribus, inferioribus rectangulis, infimis majoribus subdilatatis. Folia perichaetialia oblonga, subito breviter cuspidata, subintegra vel ad basin acuminis sinuolata. Capsula in pedicello tenui, erecto, rubello, 1–1.5^{cm} longo, horizontalis, inclinata suberectave, minuta, ovata, vix 1^{mm} longa, 0.5–0.7^{mm} crassa, laevis, sicca sub orificio non constricta, collo brevi, operculo rostrato. Sporae irregulares, diam. 8–20μ. *Plate XXIV.*

Delaware: Hampstead, depression in base of a chestnut tree (A. J. Grout, 1899).

Allied to *P. elegans* Sch., but easily distinguished from it by the shorter leaves, more abruptly and broadly acuminate, the rameal rather strongly denticulate in the upper third, the perichaetial bracts subentire, with a shorter acumen, the smaller capsule, the beak of the lid thinner, and the monoicous inflorescence.

Amblystegium laxirete Card. & Thér., sp. nova.—E sectione *A. riparii*, sat robustum, fluitans, sordide viride, usque 10^{cm} longum, vage pinnatum, ramis inaequalibus patulis, attenuatis, laxe foliosis. Folia compressa, distiche patula, ovato-lanceolata, breviuscule acuminata, circiter 3^{mm} longa, 1^{mm} lata, marginibus planis integris, costa valida, 100μ basi crassa, longe ultra medium evanida, rete laxo, cellulis 60–80μ longis, 12μ latis, parietibus angustis, mollibus. Caetera ignota. *Plate XXV.*

Missouri: Monteer, in spring (B. F. Bush, 1899).

The leaves shorter acuminate, the longer and thicker costa, and chiefly the loose areolation, at first sight distinguish this moss from *A. riparium*. The last character also separates it from *A. vacillans* Sulliv. From *A. Kochii* Br. Eur. it differs by its larger leaves and its much stronger and longer nerve.

AMBLYSTEGIUM BREVIPES Card. & Thér., Minn. Bot. Stud.

3:124. 1903.—In the note following the description of this species, this phrase has been omitted in the printing: "Differs from *A. Kochii* Br. Eur. by its leaves much more shortly and less narrowly acuminate and by the short pedicel."

Hypnum malacocladum Card & Thér., sp. nova.—Monoicum, tenellum, molle, laxiusculum, lutescenti-viride. Caulis filiformis, prostratus, denudatus, ramis ascendentibus, circa 1^{cm} longis. Folia sat remota, mollia, concava, patentia, 0.8–1.1^{mm} longa, 0.4–0.5^{mm} lata, e basi valde constricta ovata vel oblonga, latissime et brevissime acuminata, apice rotundato vel subacuto, marginibus planis integris, costa tenui simplici ad medium vel ultra producta, interdum superne subfurcata, 35–40μ basi crassa, cellulis alaribus rectangulis vel subhexagonis, hyalinis, sed auriculas distinctas non efformantibus, mediis sublinearibus, 35–70μ longis, 7μ latis, superioribus brevioribus, rhomboidalibus, parietibus crassioribus. Folia perichaetialia erecta, longius acuminata, costata. Capsula in pedicello brevi crassiusculo purpurascente, 8–10^{mm} longo, horizontalis vel oblique erecta, brevis, gibbosa, 1–1.5^{mm} longa, 0.75^{mm} crassa, operculo convexo-apiculato. Annulus simplex, distinctus. Peristomium 0.4^{mm} altum, processus in carina anguste fissi, superne papillosuli; cilia 1–2. Sporae 12μ crassae. *Plate XXV.*

North America: Without locality or name of collector, in herb. L. Debat.

This species somewhat resembles *H. Goulardi* Sch., from which it differs by its longer leaves with a single long costa. It is also distinguished from *H. Closteri* Aust. (*Amblystegium Holzingeri* Ren. & Card.) by its greater size and longer costa.

CHARLEVILLE AND LE HÂVRE, FRANCE.

EXPLANATION OF PLATES XVI–XXV.

Plate XVI.—1. *Phascum hyalinotrichum.* *a*, entire plant × 17; *b*, lower leaf × 26; *b'*, *b'*, upper leaves × 26; *c*, basal areolation × 135; *d*, areolation in the middle × 135; *e*, areolation in the upper part × 135; *f*, capsule unripe × 26; *g*, calyptra × 26.—2. *Pleuridium Bakeri.* *a*, entire plant × 17; *b*, *b*, *b*, leaves × 26; *b'*, perichaetial leaf × 26; *c*, apex of a leaf × 90; *d*, basal areolation × 200; *e*, areolation in the middle × 270; *f*, capsule with calyptra, in moist state × 26; *g*, capsule in moist state × 26; *h*, calyptra × 26.

Plate XVII.—1. *Dicranum alatum.* *a*, *b*, leaves × 13; *c*, part of a leaf

1a
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1c
1d
1e
1f
1g
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2d
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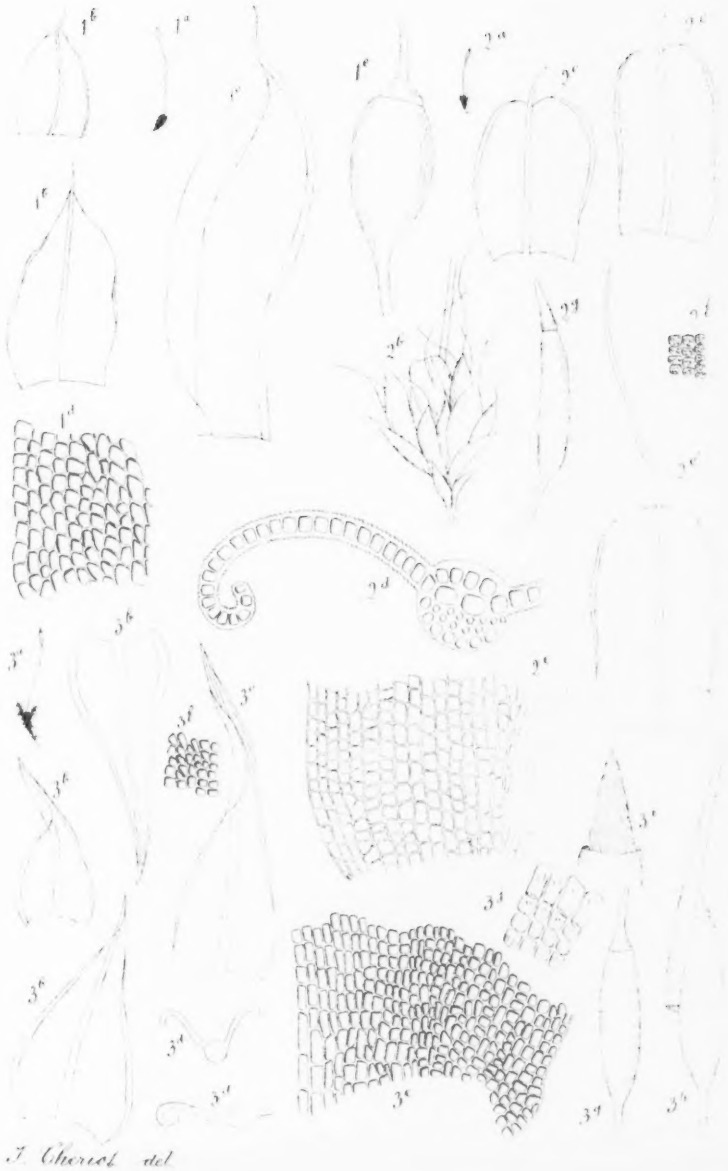
2h
J. Thériot del.

J. Thériot del



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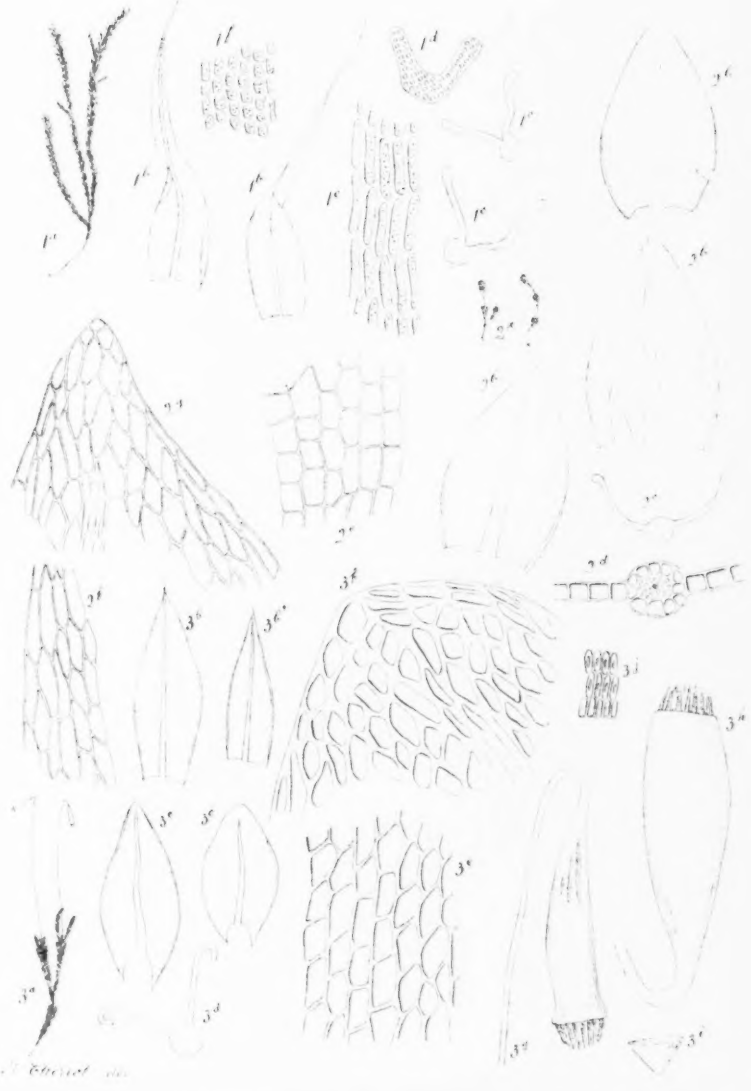

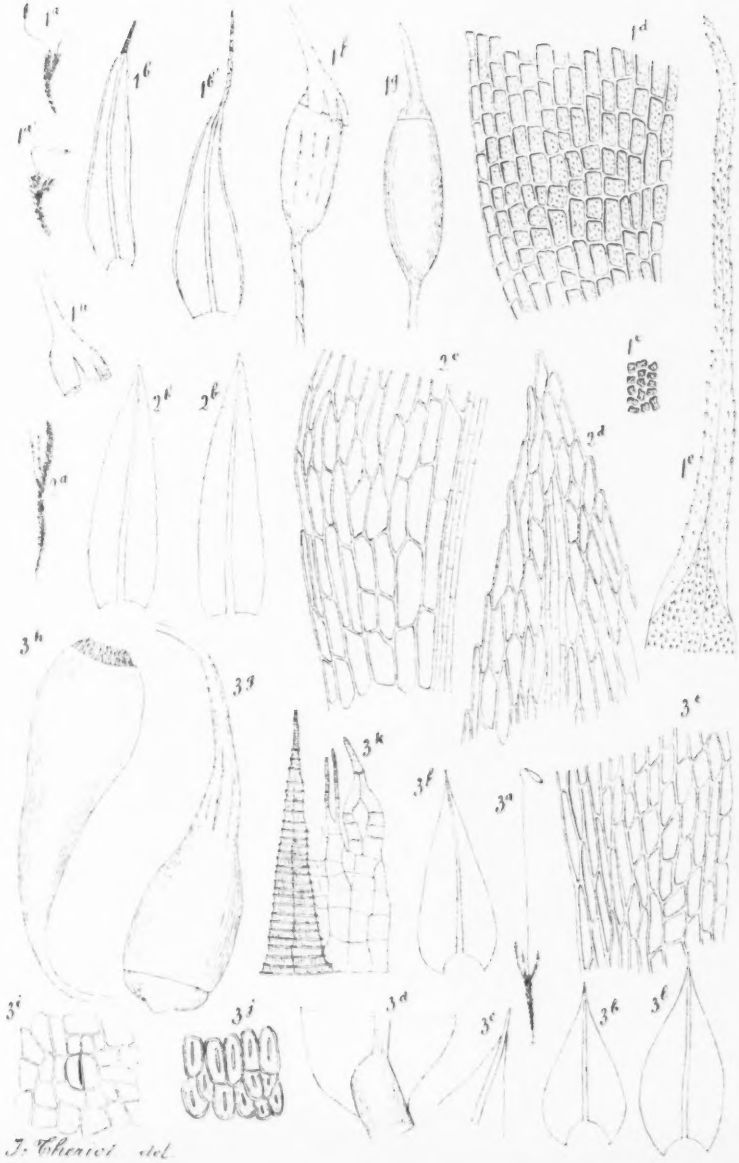
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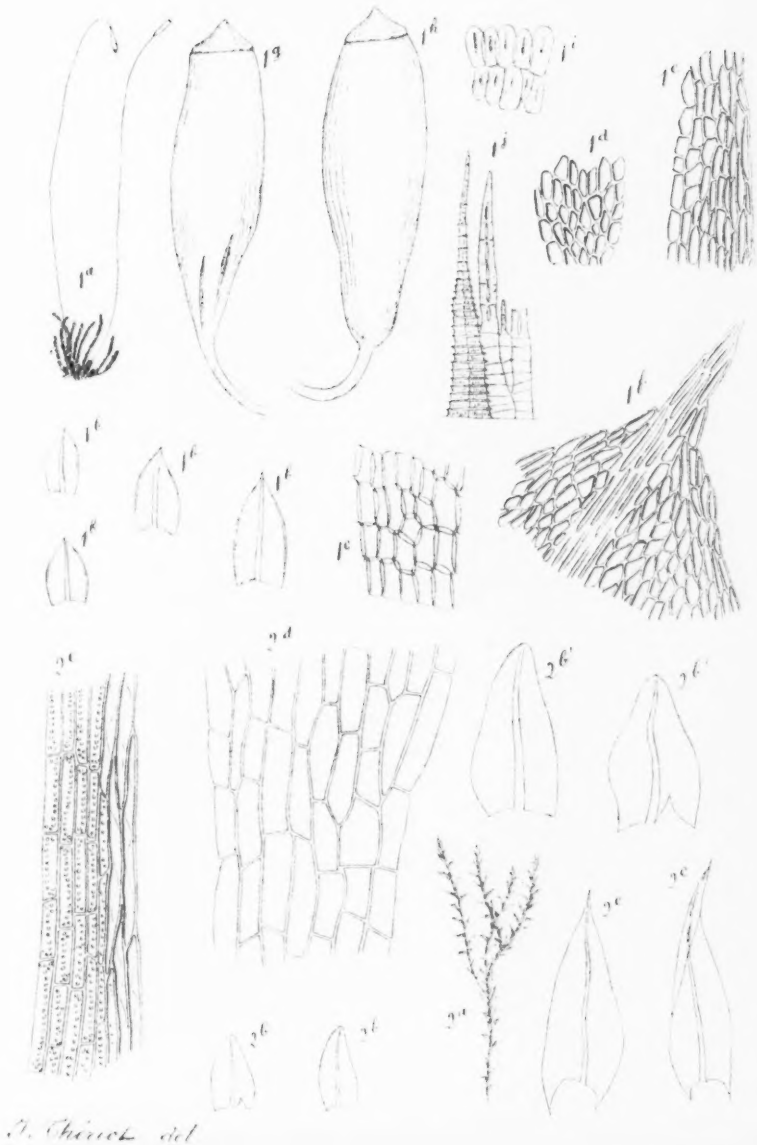
J. Thériot del.



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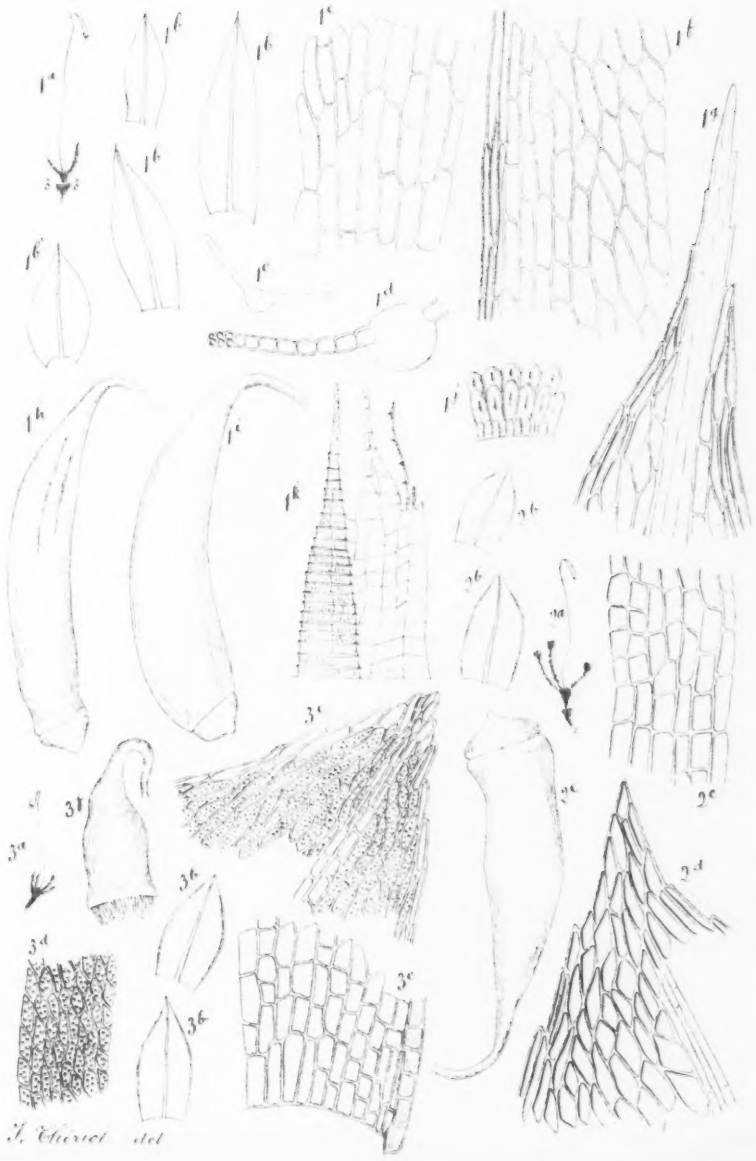
J. Thériot del

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1b
1c
1d
1e
2a
2b
2c
2d
2e
J. Thériot del.

J. Chevrot del

J. Cheriot del

× 90; *d, d, d*, transverse sections of a leaf × 90; *e*, transverse section of the costa × 200; *f*, alar cells × 200; *g*, basal areolation × 200; *h*, middle cells × 200; *i*, areolation in the upper part × 200.—2. *Fissidens Bushii*. *a*, entire plant, nat. size; *b, b*, leaves × 26; *c*, marginal areolation in the middle × 270; *d*, areolation in the upper part × 270.—3. *Desmatodon Bushii*. *a*, entire plant, nat. size; *b, b, b*, leaves × 13; *b'*, *b'*, perichaetial leaves × 13; *c*, basal areolation × 200; *d*, areolation in the upper part × 200; *e*, capsule with calyptra × 13; *f*, capsule in dry state × 13; *g*, peristome × 26; *h*, portion of the peristome × 200.

Plate XVIII.—1. *Pottia nevadensis*. *a*, entire plant, nat. size; *b, b*, leaves × 26; *c*, perichaetial leaf × 26; *d*, areolation in the middle of a leaf × 135; *e*, capsule in moist state × 13.—2. *Barbula macrotricha*. *a*, entire plant, nat. size; *b*, lower part of the same × 13; *c, c*, lower leaves × 26; *c'*, upper leaf × 26; *d*, transverse section of a leaf × 200; *e*, basal areolation × 135; *f*, middle cells × 135; *g*, capsule × 13.—3. *Barbula Bakeri*. *a*, entire plant, nat. size; *b, b, b*, leaves × 13; *c*, perichaetial leaf × 13; *d, d*, transverse section of the leaf × 90; *e*, basal areolation × 200; *f*, middle cells × 200; *g*, capsule in moist state × 13; *h*, capsule with calyptra × 13; *i*, peristome × 30; *j*, portion of the persistent annulus × 200.

Plate XIX.—1. *Grimmia cognata*. *a*, entire plant, nat. size; *b, b*, leaves × 13; *c, c*, transverse sections of the leaf × 60; *d*, transverse section of the leaf in the upper part × 80; *e*, basal areolation × 270; *f*, areolation in the upper part × 270.—2. *Bryum anceps*. *a*, entire plant, nat. size; *b, b, b*, leaves × 26; *c*, transverse section of the leaf × 26; *d*, transverse section of the nerve × 105; *e*, basal areolation × 135; *f*, marginal areolation in the middle × 135; *g*, areolation in the upper part × 135.—3. *Bryum dimorphophyllum*. *a*, entire plant, nat. size; *c, c*, lower leaves × 13; *b*, upper leaf × 13; *b'*, perichaetial leaf × 13; *d*, transverse section of the leaf × 60; *e*, areolation in the middle × 270; *f*, areolation of the upper part × 270; *g*, capsule ripe and deoperculate, in dry state × 73; *h*, the same in moist state × 13; *i*, lid × 13; *j*, portion of the annulus × 135.

Plate XX.—1. *Grimmia Hendersoni*. *a*, entire plant, in dry state, nat. size; *a'*, the same, in moist state, nat. size; *b*, lower leaf × 13; *b'*, upper leaf × 13; *c*, point of the same × 60; *d*, basal areolation × 200; *e*, middle cells × 200; *f*, capsule with calyptra, in dry state × 13; *g*, capsule operculate, in moist state × 13.—2. *Webera Debati*. *a*, entire plant, nat. size; *b, b*, leaves × 32; *c*, basal areolation × 135; *d*, areolation of the upper part × 135.—3. *Webera chlorocarpa*. *a*, entire plant, nat. size; *b, b*, leaves × 13; *c*, apex of a leaf × 32; *d*, base of a leaf × 32; *e*, marginal areolation in the middle × 135; *f*, perichaetial leaf × 13; *g*, capsule in dry state × 13; *h*, capsule deoperculate, in moist state × 13; *i*, capsular membrane with a stomata × 135; *j*, portion of the annulus × 135; *k*, portion of the peristome × 90.

Plate XXI.—1. *Bryum polycladum*. *a*, entire plant, nat. size; *b, b, b, b*, leaves × 13; *c*, basal areolation × 135; *d*, middle cells × 135; *e*, marginal

areolation in the middle × 135; *f*, areolation of the apex × 135; *g*, capsule in dry state × 13; *h*, the same in moist state × 13; *i*, portion of the annulus × 135; *j*, portion of the peristome × 90.—2. *Bryum distantifolium*. *a*, entire plant, nat. size; *b*, *b*, lower leaves × 13; *b'*, *b'*, the same × 26; *c*, *c*, upper leaves × 13; *d*, basal areolation × 135; *e*, marginal areolation in the middle × 135.

Plate XXII.—1. *Bryum camptocarpum*. *a*, entire plant, nat. size; *b*, *b*, *b*, stem-leaves × 13; *b'*, branch-leaf × 13; *c*, transverse section of a leaf × 60; *d*, the same × 135; *e*, basal areolation × 135; *f*, marginal areolation in the middle × 135; *g*, apex of the leaf × 135; *h*, capsule in dry state × 13; *i*, the same, in moist state × 13; *j*, portion of the annulus × 135; *k*, portion of the peristome × 90.—2. *Bryum subdrepanocarpum*. *a*, entire plant, nat. size; *b*, *b*, leaves × 13; *c*, basal areolation × 135; *d*, areolation of the upper part × 135; *e*, capsule in dry state × 13.—3. *Bryum brevicuspis*. *a*, entire plant, nat. size; *b*, *b*, leaves × 13; *c*, basal areolation × 135; *d*, middle cells × 135; *e*, areolation of the apex × 135; *f*, capsule in dry state × 13.

Plate XXIII.—1. *Bryum sanguilentum*. *a*, entire plant, nat. size; *b*, *b*, leaves × 13; *c*, marginal areolation in the middle × 135; *d*, areolation of the apex × 135; *e*, capsule in dry state × 13; *f*, the same in moist state × 13.—2. *Fontinalis subcarinata*. *a*, entire plant, nat. size; *b*, portion of the stem × 4; *c*, stem-leaf × 13; *c'*, lateral stem-leaf × 13; *d*, *d*, branch leaves × 13; *e*, basal areolation × 135; *f*, areolation in the middle × 135; *g*, areolation of the apex × 135.

Plate XXIV.—1. *Brachythecium subasperrimum*. *a*, entire plant, nat. size; *b*, *b*, branch-leaves × 26; *b'*, stem-leaf × 26; *c*, apex of a branch-leaf × 60; *d*, basal areolation of a stem-leaf × 200; *e*, middle cells × 200; *d'*, *d'*, perichaetial leaves × 26; *e'*, transverse section of the pedicel × 60; *f*, capsule ripe × 13.—2. *Plagiothecium sulcatum*. *a*, entire plant, nat. size; *b*, *b*, *b*, leaves × 26; *c*, basal areolation × 135; *d*, middle cells × 135; *e*, apex of a leaf × 135; *f*, *f*, perichaetial leaves × 26; *g*, capsule unripe in dry state × 13; *h*, capsule ripe, in dry state × 13.—3. *Plagiothecium Groutii*. *a*, entire plant, nat. size; *b*, stem-leaf × 26; *e*, apex of a stem-leaf × 135; *c*, branch-leaf × 26; *d*, apex of a branch-leaf × 135; *f*, middle cells × 200; *g*, basal areolation × 200; *h*, perichaetial leaf × 26; *i*, capsule ripe, in moist state × 13.

Plate XXV.—1. *Amblystegium laxirete*. *a*, entire plant, nat. size; *b*, leaf × 26; *c*, basal areolation × 200; *d*, areolation in the middle × 200; *e*, areolation of the apex × 200.—2. *Hypnum malacocladum*. *a*, entire plant, nat. size; *b*, *b*, *b*, leaves × 32; *b'*, perichaetial leaf × 32; *c*, basal areolation of a leaf × 270; *d*, areolation in the middle × 270; *e*, areolation of the apex × 270; *f*, capsule unripe, in dry state × 15; *g*, the same, in moist state × 15; *h*, portion of the annulus × 90; *i*, portion of the peristome × 90.

BRIEFER ARTICLES.

PHYSICAL PROPERTIES OF BOG WATER.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LVII.

THAT many plants growing typically in the peat bogs of the northern United States and Canada exhibit the same structural characters as do those occurring in very dry soils of the same region has long been known by students of plant distribution. But the question why these so-called xerophytic swamps differ so entirely in the nature of their vegetation from the drained or river swamps near by has never received a decisive answer. The idea is generally current among workers in this field that the factor determining the nature of the vegetation in bog areas lies, somehow, in the nature of the soil. Schimper states clearly that only xerophytes thrive in peat bogs, "because of the humous acids in the soil."[1] In another place (*l. c.*, p. 4) he says that a soil may be "physiologically dry" for various reasons, among which are (1) "abundance of soluble salts" and (2) "richness of the soil in humous acids." In still another place (*l. c.*, p. 657) the same writer describes the sphagnum bog ("high moor") as having a soil solution which "contains humates of alkalis in solution besides the humous acids," in which character these bogs differ from the "meadow moors," or grassy marshes.

It becomes evident immediately that if the "physiological dryness" of the bog be due to humous acids or humous salts, these substances may check absorption of water by plants either physically — by high osmotic pressure — or chemically — by toxic or stimulation effects. The question as to whether or not bog waters have a concentration appreciably higher than those of river and lake swamps near by should be easy of answer. Therefore, in 1901, the writer began a series of determinations of the osmotic pressure of the bog waters which were available. By the well-known Beckmann apparatus, determinations of the lowering of the freezing point were made, and from the data thus obtained the approximate osmotic pressure of the solution at 25° C. was calculated.[2]

[1] SCHIMPER, A. F. W., Plant geography upon a physiological basis. Translated by W. R. Fisher. Oxford. 1903. P. 8.

[2] For methods of procedure see LIVINGSTON, B. E., The rôle of diffusion and osmotic pressure in plants, part I, chap. VI. Chicago. 1903.

Bog water has now been studied from a number of widely distant localities, namely: from Aetna and Millers, Ind. (at the southern end of Lake Michigan); from Oconomowoc, Wis.; from Grand Rapids, Mich.; from Ann Arbor, Mich.; from Toms River, N. J.; and from near Port Jervis, N. J. The results obtained are tabulated below, together with a brief characterization of the flora of the bogs. Data for $\frac{1}{100}$ sea water are given for comparison. In the table, lowering of the freezing point, due to dissolved substances, is given in degrees centigrade. The osmotic pressure is given in millimeters of a mercury column and also in terms of M, which represents the pressure developed in a molecular solution of any non-electrolyte.

TABLE OF PHYSICAL PROPERTIES OF NATURAL WATERS.

Source of Water	Nature of Vegetation	Lowering of Freezing Point (degrees C.)	Calculated Osmotic Pressure	
			Mm. of Hg	M
Drained swamps of Hackensack River, N. J.		0.005	50.075	$\frac{29}{10000}$
New York city supply (Croton and Bronx Rivers)		0.005	50.075	$\frac{29}{10000}$
Chicago city supply (Lake Michigan)		0.01	100.15	$\frac{58}{10000}$
Grand River, Grand Rapids, Mich.		0.01	100.15	$\frac{58}{10000}$
Aetna, Ind.	Rhus Vernix, Drosera.	0.01	100.15	$\frac{58}{10000}$
Millers, Ind.	Larix, Rhus Vernix.	0.005	50.075	$\frac{29}{10000}$
Oconomowoc, Wis.[3]	Typical Larix swamp.	0.02	200.30	$\frac{117}{10000}$
Grand Rapids, Mich.	Larix, Sphagnum, Eriophorum, Oxycoccus.	0.015	150.225	$\frac{187}{10000}$
Ann Arbor, Mich.:				
First Lake Bog[4]	Larix, Chamaedaphne, Sphagnum, Aronia.	0.005	50.075	$\frac{29}{10000}$
West Lake Bog[5]	Sphagnum, Chamaedaphne, Potentilla palustris, Salix.	0.0125	125.188	$\frac{73}{10000}$
Toms River, N. J.	Chamaecyparis, Sphagnum, Chamaedaphne, Sarracenia, Oxycoccus.	Average of 13 tests, 0.0057 Max., 0.017 Min., 0.0025	57.086 170.26 25.038	$\frac{33}{10000}$ $\frac{99}{10000}$ $\frac{15}{10000}$
Port Jervis, N. J.[6]	Aronia, Chamaedaphne.	0.006	60.090	$\frac{35}{10000}$
$\frac{1}{100}$ sea water		0.0225	250.075	$\frac{146}{10000}$

[3] This water was obtained for me by Dr. H. C. Cowles.

[4] This lake and its bog are described in detail by Weld, L. H., Botanical survey of the Huron River Valley. II. A peat bog and morainal lake. Bot. Gaz. **37**: 36–52. 1904.

[5] This lake and bog are described by Reed, H. S., A botanical survey of the Huron River Valley. I. The ecology of a glacial lake. Bot. Gaz. **34**: 125–139. 1902. These Ann Arbor waters were obtained by the kindness of Mr. E. N. Transeau.

[6] This water was obtained through the kindness of Dr. C. C. Curtis, of Columbia University.

The tests here recorded were made in the summer, autumn, and winter, several bogs being studied both in the dryest part of the former season and in the middle part of the latter. These last-named tests showed practically no difference in osmotic pressure corresponding to

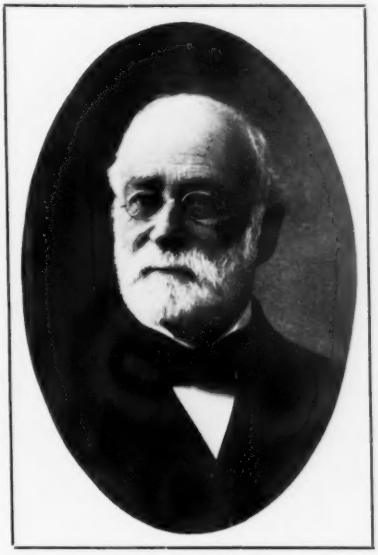
the season. Keeping the bottled water for months and even years does not alter its osmotic pressure appreciably.

The conclusion to be drawn from the material just presented is simply that *bog waters do not have an appreciably higher concentration of dissolved substances than do the streams and lakes of the same region.* Thus we are driven to the idea that if there is any property of bog water which prevents ordinary swamp plants from growing therein, this property must rest upon the chemical nature of the very small amounts of dissolved substances present. The nature and physiological properties of these bodies the writer is now studying.—BURTON EDWARD LIVINGSTON, *Hull Botanical Laboratory, The University of Chicago.*

WILLIAM M. CANBY.

(WITH PORTRAIT)

THE announcement of the death of Mr. William M. Canby, of Wilmington, Delaware, will come as a personal loss to botanists throughout the country, for he has been as well the intimate friend of many of them as a most generous contributor to all our public and private herbaria. Although Mr. Canby had not been in the best of health for some time, his condition was not such as to cause any serious alarm to his friends. On February 23 he went south for rest and change, but he contracted a severe cold, which was followed by a chill, and died very suddenly March 10, at North Augusta, South Carolina.



William Marriott Canby was born in Philadelphia, Pennsylvania, March 17, 1831, thus being nearly 73 years of age at the time of his death. He received his early education at the Friends School at Westtown, near West Chester, Pennsylvania, and from private tutors.

Although to most readers of this sketch Mr. Canby is known only as a botanist or as a collector, he was all his life a most industrious business man. The mere mention of the various enterprises in which he was engaged shows that he was a man of much importance in his community. For many years he was engaged in railroad business as receiver, president, or director, holding the last position in connection with one of the branches of the B. & O. Railway at the time of his death. He was also a director in various banking and trust companies, and for twenty-four years had been president of the Wilmington Savings Fund Society, one of the most substantial institutions of his home city. As a member and president of the Park Commission of Wilmington for more than twenty years, he rendered most valuable service to the community, and the beautiful park system of Wilmington is said to be largely due to his efforts. In politics he was a Republican, but was elected to the city council as an independent for the purpose of doing away with public graft and a corrupt political ring.

Mr. Canby early developed a love for botany, and as long ago as 1858 began collecting plants, and for the remainder of his life was an enthusiastic collector, distributing his material with a lavish hand to those who showed even the least interest in it. He traveled extensively, and always went prepared to care for rare or strange plants which he might find. His knowledge of the plant life of his own state and the "eastern shore" region of Maryland was very great. One of my pleasantest recollections of him is in connection with an excursion of several days in this region. His knowledge of the plants, their haunts, their names, their peculiarities, astonished me. His method of work was that of an enthusiast. Stopping at some good collecting ground, he would spend several hours gathering specimens, reaching the station just in time to make his train, spending the next hour or so in putting away his plants, and ready to repeat the operation at the next station.

His most important work of this kind was that as botanist in charge of the Northern Transcontinental Survey of 1882–3. This was a survey undertaken by the Northern Pacific Railway Company, which planned a most extensive study of the natural history resources of the region through which the road passes. The railway company, however, finally withdrew its support, and the survey was never completed. In the meantime a great mass of material was collected containing many new species, and the specimens were afterwards freely distributed to all the large private and public herbaria.

The Canby herbarium was for many years one of the most impor-

tant herbaria in the country and was always placed at the service of monographers who wished to study it. It not only represented the forty-five years of collecting of its founder, but was increased through extensive exchanges and purchases. For years Mr. Canby bought every collection offered for sale. It was largely through the efforts of a few men, one of whom was Mr. Canby, that Parry and Palmer made their trip to San Luis Potosi, Mexico, in 1877, which yielded such an astonishing number of new plants. He also aided Mr. Pringle in his early struggles in Mexico.

In 1893 his herbarium numbered some 30,000 specimens, and was about this time sold to the College of Pharmacy of New York city, where it now remains. He had no sooner disposed of his herbarium than he began, with all the enthusiasm of a young man, to build up a new one, giving it to the Natural History Society of Delaware at Wilmington. This herbarium contains about 15,000 species at the present time. Although Mr. Canby was a very keen and able botanist, he rarely described new plants, usually contenting himself with pointing out differences and permitting specialists to publish the results of his discoveries.

Quite a number of plants have been named in his honor. The genus Canbya, though named by Dr. C. C. Parry, was described by Dr. Asa Gray in the Proceedings of the American Academy in 1876. Among the species I recall the following: *Angelica Canbyi* C. & R., *Crataegus Canbyi* Sargent, *Hydrocotyle Canbyi* C. & R., *Ligusticum Canbyi* C. & R., *Lobelia Canbyi* Gray, *Pachystima Canbyi* Gray, *Pedicularis Canbyi* Gray, *Peucedanum Canbyi* C. & R.

Although Mr. Canby never wrote any extensive work, he was an occasional contributor to botanical journals, and some eleven articles in this journal were furnished by him. Mention should be made of his very valuable contributions to the study of insectivorous plants, especially in connection with Dionaea and Darlingtonia. Darwin made free use of his observations and refers to his work in high terms. In his writings he always referred to Mr. Canby as "Dr. Canby," although I belive he never received a degree of any kind. He once told the writer that one of our American colleges had offered him the degree of Ph.D., but he declined it.—J. N. Rose, *U. S. National Herbarium, Washington, D. C.*

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ANATOMY OF COTYLEDONS.

LAST year the writer published a short article[1] describing some observations on the anatomy of cotyledons with a comparison of cotyledons and foliage leaves in the Papilionaceae. In that paper it was stated that the study would be continued to other plant families. This has been done in the case of representative species of the Cruciferae and Ranunculaceae by two graduate students, Miss Neata Clark and Miss Martha Phelps. A further investigation will be made in these same families and with other families.

In the Ranunculaceae and Cruciferae studied there is not as great a difference in structure between cotyledons and leaves as was seen in the Papilionaceae. Thus the form of the epidermal cells is frequently the same in the two structures. There are, however, some differences in the arrangement and number of stomata, these being sometimes absent from one surface of the leaf, but present on both surfaces of the cotyledon. The trichome structures are frequently absent from the cotyledon when present on the leaf, and sometimes when present on the cotyledon they are of special form.

[1] University of Colorado Studies **1**: 239–243. 1903.

The stalks of the cotyledon and leaf are quite different in anatomical structure. In all cases the vascular tissue of the cotyledon stalk is placed in the center, and is for the most part organized as a single vascular bundle. In the leaf stalk the vascular tissue has the usual arrangement, the bundles being three or more in number and placed in the form of a circle or a partial circle or ellipse.

In these families, as in the Papilionaceae, there seems to be no relation in external form between the cotyledon and leaf. Whether it will be considered best to continue the use of the name "seed leaf" for cotyledon must depend on other things than mere anatomy of the structures considered, but the writer believes that further study will bring the problem of the cotyledon nearer solution.—FRANCIS RAMALEY, *University of Colorado, Boulder, Colo.*

CURRENT LITERATURE.

BOOK REVIEWS.

Plant physiology.

GERMAN PHYSIOLOGISTS all seem to have been resting on their oars, awaiting the forthcoming volumes of Pfeffer. Not since the publication of Sachs's lectures has a book of any considerable size appeared in Germany, though Detmer's work, a part of Schenck's *Handbuch*, could be purchased separately. Dr. Ludwig Jost[1] of Strassburg has been engaged for several years on a volume intermediate between the monumental work of Pfeffer and the brief treatment of physiology by Noll in the "Bonn" *Lehrbuch*.

As a result of his labors we have a volume of almost 700 pages, treating in a critical and yet synoptic fashion the metabolism, the morphogeny, and the energetics of plants. The work takes the form of lectures, and by this device retains a vigor of phrase and fitness of description that is impossible in a more formal type of composition. The sentences are clear, direct, and forceful, and the style is consequently most attractive. In this it stands in sharp contrast with the work of Pfeffer, whose completion we note below.

Jost gathers up the literature through 1902 and exhibits critical acumen in sifting the mass of data which have accumulated. The section on metabolism treats the usual topics, somewhat more space being given to the ash constituents of plants perhaps than the reliable data will justify. Under the heading carbon and nitrogen the author discusses photosynthesis and proteid making, as well as respiration, digestion, fermentation, and other processes. So general a heading, therefore, is hardly useful, since all the metabolism of plants is connected with these two elements. Unfortunately, the author continues the use of the term "assimilation" for the synthetic processes which really precede true assimilation, and we have such divisions as *Assimilation bei den Autotrophen* and *Assimilation bei den Heterotrophen*, two processes which are so unlike that the identical terminology is sure to be confusing.

A second section of the book treats morphogeny (*Formwechsel*) rather more fully than is usual, but not more so than is desirable; to it almost one-third of the book is devoted. Besides the consideration of growth and development and the influence of external factors thereon, reproduction, heredity, and variation find adequate treatment. The section on reproduction is not a mere description of reproductive organs, as is so commonly the case, but a discussion of the physiological processes that are connected with these organs.

[1] JOST, LUDWIG, Vorlesungen über Pflanzenphysiologie. Imp. 8vo. pp. xiii + 695. *figs. 172*. Jena: Gustav Fischer. 1904. *M*13; bound *M*15.

In a third section, *Energiewechsel*, the author discusses movements of all kinds, whether due to warping, to growth, or to turgor variations.

The scope of this work, its freshness, conciseness, and not least its clear and pleasing style, will commend it to every reader. It is easily the best work on plant physiology in any language for the general student. We hope that it will be translated promptly into English, though the necessity for this is not so great as in the case of some less readable works.—C. R. B.

THE LAST PART of the second volume of Pfeffer's *Pflanzenphysiologie*[2] has recently made its appearance from the press of Wilhelm Engelmann at Leipzig. Its publication, indeed, is almost simultaneous with the English translation of the first part of the same volume. We may therefore expect that the usual two years will elapse before this final part is translated into English. This portion is devoted entirely to the movements of plants, except a short chapter on the production of heat, light, and electricity, and a synoptical account of the forms and amount of energy exhibited in plants. In the discussion of movement one feels still more strongly the lack of coordination which is a marked characteristic of the whole work. The field in which there was needed the utmost clarity of statement and organization of facts is naturally the one in which the lack of such definite organization and clear presentation is most felt. But in spite of this serious fault one finds the same suggestiveness in the treatment of the various topics that has likewise characterized the preceding portions of the work. The same concise bibliography (notwithstanding the often incomplete citations) puts one into immediate touch with the more important literature. It is as impossible as it is unnecessary to go into detail in reviewing this volume. The mere announcement of its publication is all that is needed to insure its purchase by every institution in which plant physiology has a place and by every student who touches more than the rudiments. And the German original is as important to the investigator as the more easily read translation.—C. R. B.

THE SECOND INSTALLMENT of the English edition of Pfeffer's *Physiology of Plants*[3] has recently appeared. Its sub-title is *Growth, reproduction, and maintenance*. The present volume is both more and less than a translation. Dr. Ewart's aim has been to transfer the meaning into good English without undue regard to the original form, so that many of the involved paragraphs of the author may be said to be interpreted rather than translated. This is usually a distinct improvement, and can cause serious trouble only in those comparatively rare cases where the author's meaning is not quite

[2] PFEFFER, W., Pflanzenphysiologie: ein Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze. Zweiter Band: Kraftwechsel. 2. Hälfte. Imp. 8vo. pp. xi + 353 to 986. *figs. 60.* Leipzig: Wilhelm Engelmann. 1904. *M*19. Parts 1 and 2 of Vol. II, *M*30; bound *M*33.

[3] EWART, A. J., Pfeffer's Physiology of Plants, Vol. II. Growth, reproduction, and maintenance. 8vo. pp. viii + 296. *figs. 31.* Oxford: The Clarendon Press. 1903

clear. But there are places where certain finer shades of meaning in the original are not reproduced in the translation. These, of course, are the passages wherein Pfeffer's personality and suggestiveness of mind are hinted at by form of statement, and it thus comes about that the English volume contains somewhat less of Pfeffer and more of Ewart, albeit its physiology is more concisely put than in the German edition. Also, while the entire omission in the translation of the author's numerous parenthetical cross references to other sections of the same work makes the text more readable, it cannot but be regretted that the volume has thus been robbed of one of the most characteristic and valuable features which the original possessed for research workers. For the latter class of English readers the German edition will still be in demand, though no place where physiology is studied can afford to be without the translation.

In form, typography, etc., this volume follows the previous English volume and leaves nothing to be desired. The footnotes which cite the literature are usually merely translated, and have all the good and bad qualities of those of the original.— B. E. LIVINGSTON.

Plant geography.

THE appearance of the English edition of Schimper's great masterpiece[4] has been long awaited with impatience by all English and American botanists. During the latter part of 1903 the Clarendon Press issued the translation in instalments, and the completed work has been recently distributed. Every ecologist — one wishes he might say every botanist — has a well-thumbed copy of the original German edition upon his desk, and it has been one of the reference books most consulted during the past five years. Perhaps to such the appearance of a translation is too late to be of the greatest service. But to the reading public and to the students of botany in high schools, colleges, and universities the translation makes readily accessible this indispensable work. There can no longer be any reason for omitting ecological work from the higher botanical curricula.

The translation was prepared by W. R. Fisher, under the efficient supervision of Groom and Balfour. An excellent photogravure portrait of Schimper forms the frontispiece. This is a particularly welcome addition, since it has been very difficult to secure satisfactory portraits of the great ecologist. Another addition in the English edition is a sympathetic appreciation of Schimper, written by Groom.

One cannot praise too highly the laborious faithfulness to the original, which is shown in the translation. No unfortunate attempts are made to

[4] SCHIMPER, A. F. W., Plant geography upon a physiological basis. Authorized English translation by WILLIAM R. FISHER; revised and edited by PERCY GROOM and ISAAC BAYLEY BALFOUR. With a photogravure portrait, five collotypes, four maps, and four hundred and ninety-seven other illustrations. Imp. 8vo. pp. xxx + 839. Oxford: Clarendon Press. 1903. *Sh.* 42.

improve upon Schimper's thought or diction; very few liberties indeed are taken. In isolated cases the text might be clearer to American readers, if other renderings were used. For example, it may be doubted if *guild* is the best equivalent of *Genossenschaft*, or *elfin-tree* of *Krummholz*. The reviewer sees no objection to retaining the word *Krummholz* in English until an equivalent appears.

The presswork is admirable; even the illustrations seem to be quite equal to those of the original. Both the original and the translation are large and bulky volumes, and it would seem that the advantages of a two-volume edition would more than outweigh the obvious disadvantages. We hope and expect that the belief of Groom and Balfour, stated in the preface, will be realized, viz., that this work will have as great an influence upon current botanical movements as was exerted by the translation of Sachs's *Text-book of Botany* thirty years ago.—HENRY C. COWLES.

Paleobotany.

The modern morphologist is always anxious to secure some definite information concerning paleobotanical material and welcomes every new publication that promises to be helpful. Flahault[5] has just published a résumé of certain paleobotanical conferences he has been in the habit of holding with students at Montpellier, as a preliminary to work with living plants. It is really a brief and simple account of our knowledge of fossil plants and of their relation to modern vegetation. The curious autolithographic preparation of the book, including illustrations, gives to it almost the flavor of a long personal letter. The seven chapters deal with the following subjects: (I) Introductory remarks; (II) Thallophytes; (III) Bryophytes, Characeae, Pteridophytes, and groups of doubtful affinity; (IV) Phanerogamic plants—Gymnosperms; (V) Angiosperms; (VI) Differentiation of climates; successive constitution of floras; (VII) General results and conclusions.

The book will doubtless be of great service in many laboratories where a brief and clear account of the paleobotanical evidence is much needed.—J. M. C.

MINOR NOTICES.

DR. JANET PERKINS[6] has begun a series of publications devoted to the investigation of the flora of the Philippine Islands. The author's work is based upon the old and new collections belonging to the Berlin Museum, and other collections that the Museum has been able to call in; and she has also secured special monographers as collaborators. The first fascicle is chiefly

[5] FLAHAULT, CH., La paléobotanique dans ses rapports avec la végétation actuelle. Autolithograph, pp. 217. Paris: Paul Klincksieck, 3 rue Corneille. fr. 7.50.

[6] PERKINS, JANET, Fragmenta florae Philippinae. Contributions to the flora of the Philippine Islands. Fasciculus I. pp. 1–66. Leipzig: Gebrüder Borntraeger. 1904. *M* 4.

made up of the beginning of an enumeration of some of the recently collected plants of Ahern, Jagor, Loher, Merrill, Warburg, and others; and the novelties are very numerous, the region promising to equal any other in the world in this regard. The Leguminosae (7 n. spp.), Dipterocarpaceae (2 n. spp.), Anacardiaceae (8 n. spp.), Meliaceae (4 n. spp.), Pinaceae, and Taxaceae are by Dr. Perkins; Symplocaceae (1 n. sp.) by A. Brand; Acanthaceae by G. Lindau; Fagaceae by O. von Seemen; Typhaceae by P. Graebner; Orchidaceae by R. Schlechter; Palmae (6 n. spp.) by O. Beccari; Myristicaceae (1 n. sp.), Pandanaceae (1 n. sp.), and Begoniaceae (10 n. spp.) by O. Warburg; and Sapindaceae (10 n. spp.) by L. Radlkofer.—J. M. C.

IN A LITTLE WORK intended for beginners, Walmsley[7] gives a detailed account of the processes of elementary photomicrography and lantern-slide making. The book is intended for those who have little or no knowledge of general photography, and presupposes that the learner will have a student microscope and field camera. After chapters on microscopes and optical apparatus, cameras and appliances, and various radiants (among which he justly gives a high place to acetylene), the various processes for medium and low power photography receive minute attention. For work of little amplification the use of short-focus photographic lenses is recommended, but the experienced worker, acquainted with modern lenses, wonders why a "rapid rectilinear" is advocated for such work. A table giving radiant, amplification, time of exposure, etc., is of value to those who have had little experience. —W. J. G. LAND.

THE FIFTH PART OF ROTH'S *Europäischen Laubmoose*, completing the first volume, has appeared.[8] The volume contains 24 families of cleistocarpic and acrocarpic mosses, the Bryaceae beginning the second volume. Corrections and additions occupy 12 pages. The described species and the synonyms are listed, unfortunately, in two indexes, printed alike and with no page heading to distinguish them. These editorial and typographical faults will cause much inconvenience in using the book, partly defeating the author's laudable desire to save his fellows time in determining the mosses. From the preface we learn that in case the work meets the approval of bryologists the author contemplates publishing his labors on exotic species, of which he has already nearly 3000 drawn.—C. R. B.

LEROY ABRAMS, of Leland Stanford Junior University, has published a *Flora of Los Angeles and vicinity*,[9] which includes the coast slope of Los

[7] WALMSLEY, W. H., The A B C of phto-micrography. 8vo. pp. 155. *pls.* 13. New York: Tennant and Ward. 1902. $1.25.

[8] ROTH, G., Die europäischen Laubmoose. Erster Band. Kleistokarpische und akrokarpische Moose bis zu den Bryaceen. Leipzig: Wilhelm Engelmann. 1904. *M* 25. See BOT. GAZ. **37**: 150. 1904.

[9] ABRAMS, LEROY, Flora of Los Angeles and vicinity. pp. xi + 474. Stanford University, California: Stanford University Press. 1904.

Angeles and Orange counties. The wonderful diversity of the flora of California compels separate manuals for different regions of the state, if they are to be kept within convenient compass. No one of these regions seems to have been in greater need of such a manual than the one selected by the author. The usefulness of such a book is to be determined in the using, but the page is clear and attractive, the keys are well organized for convenience, and the specialists called on for assistance are abundantly able to give it. The book should justify fully the evident pains given to its preparation.—J. M. C.

A KEY to the genera of the native and cultivated woody plants of New York state, as they appear in their winter condition, has been issued recently from Cornell University.[10] One hundred and eighty-two genera are considered, including such plants as Epigaea. The distinguishing characters of the deciduous genera are chiefly those of buds, twigs, and leaf scars. The key will be especially helpful in determining the cultivated trees and shrubs of the city parks. The authors intend later to present keys to the species of each genus.—C. D. HOWE.

A CATALOGUE of the bryophytes and pteridophytes of Pennsylvania, prepared by the late Professor Thomas C. Porter[11] and edited by Dr. John K. Small, has just been published. The liverworts number 91 species and varieties, mosses 366, ferns 56, and "fern allies" 29. The catalogue is a bare list, with habitats and stations, but it is especially interesting in that Professor Porter was assisted in its preparation by such men as Thomas P. James, Coe F. Austin, A. P. Garber, and D. A. Burnett.—J. M. C.

THE THIRD VOLUME of Halacsy's[12] *Flora of Greece* begins with Lentibulariaceae, and the first fascicle closes in the midst of Cyperaceae.—J. M. C.

NOTES FOR STUDENTS.

J. H. SCHAFFNER[13] has published a partial list of Ohio plants with extra-floral nectaries and other glands, and has also referred them to eleven types.—J. M. C.

PORSCH finds[14] the study of the finer details as well as the general struc-

[10] WIEGAND, K. M. and FOXWORTHY, F. W., A key to the genera of woody plants in winter, including those with hardy representatives found growing wild or in cultivation within New York state. Ithaca, N.Y.: Cornell University. 1904. 25 cents.

[11] PORTER, THOMAS C., Catalogue of the Bryophyta and Pteridophyta found in Pennsylvania. 8vo. pp. 66. Boston: Ginn & Company. 1904. $1.10.

[12] HALACSY, E. DE, Conspectus Florae Graecae. Vol. III. fasc. I. pp. 1–320. Leipzig: Wilhelm Engelmann. 1904. *M* 7.50.

[13] SCHAFFNER, J. H., Ohio plants with extra-floral nectaries and other glands. Ohio Nat. **4**: 103–106. 1904.

[14] PORSCH, OTTO, Der Spaltöffnungsapparat von Casuarina und seine phyletische Bedeutung. Oesterr. Bot. Zeits. **54**: 7– ; 41–51. *pl. 3*. 1904.

ture of the stomata of Casuarina confirm the conclusions of Treub and others as to the phylogeny of this genus; wherefore he concludes that such data constitute a valuable adjunct to the usual phylogenetic criteria.—C. R. B.

W. C. COKER[15] has discovered that no sterile prothallial cell is cut off in the germination of the microspores of Cupressus (4 spp.), *Taxus baccata* and four vars., Juniperus (2 spp.), Chamaecyparis (5 spp.), Callitris (1 sp.), *Cryptomeria japonica*, and *Thuja orientalis*. In Thuja the four megaspores were not found in the usual linear series, but in the regular tetrad arrangement.—J. M. C.

MISS MARGARET BENSON[16] has suggested a possible origin of the angiosperm flower from the "telescoping" of such an "inflorescence" as that of Gnetum, which also suggests angiosperms in its free sporophylls, nucellar structure, embryo sac development, and vegetative characters. It may be that the possible origin of angiosperms from Gnetum-like forms has been recently too lightly considered.—J. M. C.

TWO RECENT PAPERS by Küster[17] recount the author's experiments on regeneration from the hypocotyl of seedlings of *Anagallis coerulea* and *Linaria Cymbalaria*. When the epicotyl was removed, shoots sprang from the hypocotyl, and showed a marked anisophylly. Detached cotyledons of *Cucumis sativa* produced both roots and shoots in a small proportion of cases. It is shown that anisophylly is not due to geotropism.—M. A. CHRYSLER.

W. B. HEMSLEY[18] has published some curious data in reference to Davidia, an endemic and monotypic Chinese genus usually placed in the Cornaceae. The seeds germinate while retained in the fruit, which has dehisced enough to expose them; hence from one to ten seedlings may be emerging simultaneously from a single fruit. Buds were also observed in the axils of the cotyledons.—J. M. C.

F. V. COVILLE[19] has given an account of the preparation of "wokas" by the Klamath Indians, once a staple farinaceous food of the tribe, and obtained from *Nymphaea* (*Nuphar*) *polysepala*, the great yellow water lily. The Klamath reservation is in eastern Oregon, and Klamath Marsh is estimated to contain about 10,000 acres of a solid growth of "wokas." The plant is so

[15] COKER, W. C., On the spores of certain Coniferae. Science N. S. **19**: 424. 1904.

[16] BENSON, MARGARET, The origin of flowering plants. New Phytologist **3**: 49–51. 1904.

[17] KÜSTER, E., Beobachtungen über Regenerationserscheinungen an Pflanzen. Beihefte Bot. Centralbl. **14**: 316–326. 1903; **15**: 421–426. 1904.

[18] HEMSLEY, W. BOTTING, On the germination of the seeds of *Davidia involucrata* Baill. Jour. Linn. Soc. London **35**: 556–559. *pl. 19*. 1903.

[19] COVILLE, F. V., Wokas, a primitive food of the Klamath Indians. Rep. U. S. National Museum 1902: 725–739. *pl. 13*.

vigorous that it completely excludes other characteristic and conspicuous marsh plants, such as the tule and cat-tail.—J. M. C.

RALPH E. SMITH[20] has issued a preliminary report of his investigation of the asparagus rust, a disease which is seriously threatening a great Californian industry. A complete account will be published later, but the interests involved demand such current information as is available. The account is clear and to the point, and the practical suggestions are of great value, but the wretched half-tone illustrations are almost like so much waste space in so far as they are intended to show anything distinctly.—J. M. C.

MARIANI, in a study of the influence of humidity on the development of stomata in the cotyledons,[21] seems to have obtained no very decisive results. He found that in light humidity tends to increase the area of the cotyledonar limb, but to diminish the number of stomata and (rather more) the number of epidermal cells per unit of surface, which is as much as to say that it favors the formation of stomata, but does not augment their number. In darkness the reverse effect appears, but even less distinctly.—C. R. B.

UNTIL VERY recently there has been no evidence that the Carboniferous ferns followed the same course of development as their recent allies. Within a few months a fossil sporangium, collected by Mr. J. Lomax, has been sectioned by D. H. Scott[22] and found to contain germinating spores of a quite modern type. The rhizoids in several specimens are perfectly clear, as are the cell divisions of the young prothalli. The sporangial wall in its multiseriate structure resembles those of the eusporangiate ferns.—FLORENCE LYON.

BRIOSI AND FARNETI[23] have investigated the lemon scab found in Italy, which has recently appeared in Sicily, where the natives call it *ruggine bianca*. They have identified two diseases due to the presence of a polymorphic fungus known variously as Rhynchodiplodia, Cladosporium, Hormodendron, Ovularia, Haplaria, Pseudofumago, and Pseudosaccharomyces. *Cladosporium Citri* Briosi & Farneti is the form that produces the lemon scab. The investigators produced the disease by cultures and suggest a cure.—L. MONTEMARTINI.

[20] SMITH, RALPH E., Report on asparagus rust investigation. Agricultural Experiment Station, University of California, Circular no 9, January 4, 1904.

[21] MARIANI, GINDITTA, Intorno all, influenza dell' umidità sulla formazione e sullo sviluppo degli stomi nei cotyledoni. Atti Istituto Bot. Univ. Pavia II. **8**: 67–98. 1904.

[22] SCOTT, D. H., Germinating spores in a fossil fern sporangium. New Phytologist **3**: 18–23. 1904.

[23] BRIOSI, G., and FARNETI, R., Intorno alla ruggine bianca dei limoni, grave malattia manifestatasi in Sicilia. Atti Istituto Bot. Pavia **10**:—. 1904.

SCHAFFNER,[24] in continuing his studies among the lower monocotyledons, concludes that the placing of the Nymphaeaceae near the Helobiae is justified. He holds that the embryonal and anatomical characters, as well as the more superficial features of the group, would suggest the Helobiae as near relatives. He opposes the supposition that all so-called cotyledons are homologous, and suggests that instead of having only two general types in angiosperms there are several types which approach each other at various points in widely separated orders.— R. B. WYLIE.

BACHMANN[25] has attempted to summarize our knowledge of phytoplankton, covering the whole subject, from definitions of plankton and descriptions of methods of collection to the distribution of the phytoplankton and its relation to other organisms. This is followed by a bibliography of about ten pages, and hence it cannot be very complete. The paper adds nothing to what has already been published, but gives a very good résumé of what has been done, and perhaps as good a statement of the present state of knowledge as could be expected in a brief article.—C. D. MARSH.

SEVERAL INTERESTING OBSERVATIONS regarding plasmolytic phenomena in the blue-green algae are made by Brand.[26] Among the most striking are these. Thalli of Phormidium, etc., when strongly plasmolyzed by a salt solution and then placed in pure glycerin, are able to absorb this substance much as they might water, and thus return to their normal form. They live thus, filled with glycerin, for a number of hours. Furthermore, if cells so filled with glycerin are placed in water they stretch to beyond their normal size and often burst from the high internal pressure.— B. E. LIVINGSTON.

FROM HIS STUDIES of the foliar bundles of young plants of *Cycas revoluta* and *Zamia integrifolia*, Enrico[27] concludes that, though most of the centrifugal xylem is of secondary origin, a small portion is primary and is derived from the centripetal wood. This implies a near relationship to the distinctly mesarch structure of the vascular strands of ferns. The author considers that the changes seen in a foliar bundle in its ontogeny and in its course from the leaf tip to cortex of the stem represent the phylogenetic development of the bundle of the higher plants. The phloem shows two maxima of development in its young stages; this is interpreted as an ancestral character.— M. A. CHRYSLER.

[24] SCHAFFNER, J. H., Some morphological peculiarities of the Nymphaeaceae and Helobiae. Ohio Naturalist **4**: 83–92. *pls.* 5–7. 1904.

[25] BACHMANN, H., Das Phytoplankton des Süsswassers. Bot. Zeit. **62**[2]: 81–100. 1904.

[26] BRAND, F., Ueber das osmotische Verhalten der Cyanophyceenzelle. Ber. Deutsch. Bot. Gesell, **21**: 302–309. 1903.

[27] ENRICO, C., V. Contribuzione alla conoscenza della morphologia e dello sviluppo del fascio vascolare delle foglie delle Cicadacee. Annales di Bot. **1**: 109–121. *pls.* 8–9. 1903.

IN A NEW Contribution from the Gray Herbarium, B. L. Robinson[28] publishes under the following titles: "Diagnoses and synonymy of some Mexican and Central American Eupatoriums," nine new species being described; "Synopsis of the Mikanias of Costa Rica," eleven species being recognized, three of which are new; "Notes on the genus Mimosa in Mexico and Central America," six new species being described; "Notes on some Polygonums of western North America," three new species of §Avicularia being described and the diamorphism of *P. longistylum* Small noted; "New spermatophytes of Mexico and Central America," new species being described in Hechtia, Cerastium, Parnassia, Penstemon, Piptothrix, Brickellia (2), Verbesina (2), and Liabum.—J. M. C.

J. C. ARTHUR[29] has pointed out the taxonomic importance of the spermogonium, the common conception that it is an accompaniment of the aecidium, or other spore-forms, being incorrect and misleading. After an interesting discussion of the varying life-cycles of the rusts, the statement is made that a record of the presence of the spermogonium, and the spore-generation with which it is associated, gives valuable information regarding the probable length of the cycle. If spermogonia and uredospores are found arising from the same mycelium, aecidia do not occur in the cycle; and if spermogonia and teleutospores are found arising from the same mycelium, there are neither uredo nor aecidia in the cycle. It is also stated that position, form, color, and size of the spermogonium are characters worth recording for taxonomic purposes.—J. M. C.

GOEBEL'S STUDIES on *Regeneration in Utricularia*[30] show that in the aquatic members of this genus production of adventitious buds occurs in the "leaf" forks and on the stalk of the bladders. In *U. exalata* budding occurs on leaves attached to the plant only when all vegetative points on the shoot axis are removed; hence the author emphasizes the importance of the principle of correlation. Localization of the regenerating region is ascribed not to the embryonic condition of the tissues in the leaf forks, but to the predisposition to building at places where the conducting system branches. In terrestrial species, if the tip of a leaf is cut off, buds appear on the cut surface of the attached part, but the ability to regenerate decreases rapidly as the base of the leaf is approached. Leaves of Pinguicula removed from a plant show regeneration of a more usual type, in that the adventitious buds are produced on the cut surface at base of the leaf.—M. A. CHRYSLER.

[28] ROBINSON, B. L., Contributions from the Gray Herbarium of Harvard University. New Series. no. XXVII. Proc. Boston Soc. Nat. Hist. **31**: 247–271. 1904.

[29] ARTHUR, J. C., Taxonomic importance of the spermogonium. Bull. Torr. Bot. Club **31**: 113–124. 1904.

[30] GOEBEL, J., Morphologische und biologische Bermerkungen. 15. Regeneration der Utricularia. Flora **93**: 98–126. *figs.* 17. 1904.

STEINBRINCK proposes[31] an explanation of the osmotic movement of water, which has the merit of substituting definite dynamics for the vague or ambiguous ideas of previous writers. Briefly stated he conceives the internal pressure of water to be reduced through the wedging apart of its molecules by those of the solute; the excess pressure of the pure solvent then determines its movement toward the region of least (internal) water pressure, *i. e.*, to the points where the solution is most concentrated. As the internal pressure of water has been estimated at *ca.* 10,000 atmospheres (5,000 by Tumlirz), the force concerned is entirely adequate to account for any observed movements. The osmotic cell is thus conceived as a mechanism operating by differences in internal water pressure, as the pump operates by differences in external air pressure. The explanation has no immediate relation to the kinetic theory, and Steinbrinck speaks of osmotic suction, not osmotic pressure. This conception he expounds by clear illustrations from the capillary tube and the siphon, both operating on the same principle, though the inequalities in pressure are differently produced. He also applies the idea to the problem of the ascent of sap, evidently holding the cohesion theory as the most likely.—C. R. B.

POLLACCI, who believes himself to have established the presence of formic aldehyde in green leaves (though the available tests are not beyond suspicion), now holds that he has materially strengthened his theory of photosynthesis by finding free hydrogen emitted from leaves.[32] This, he thinks, is set free in its nascent condition, in which it is a powerful reducing agent. The action normally proceeds according to the formulas: (1) $2CO_2 + 2H_2O = 2CH_2O_3$. (2) $2CH_2O_3 + 2H_2 + \text{light} = CH_2O + CH_4 + H_2O + 2O_2$. On the first step, the formation of carbonic acid, he lays considerable stress as an idea proposed by him. But in 1893[33] and repeatedly since I have insisted upon this as the first and fundamental process in photosynthesis. The second formula exhibits the course of events when adequate light and CO_2 are present. But when an excess of CO_2 is available this formula becomes: (3) $2CH_2O_3 + 3H_2 + \text{light} = CH_2O + H_2O + 2O_2 + CH_4 + H_2$. This shows Pollacci's main result in the present memoir. But he also suggests an important rôle for nascent H in the formation of many common plant products. He will continue his researches, especially to determine more accurately the compound which some of the H forms with C (appearing in the formula as "CH_4," but with probability only) and the conditions of light, temperature, electric charge, phase of development, etc., which influence the emission of free H.—C. R. B.

[31] STEINBRINCK, C., Ueber dynamische Wirkungen innerer Spannungsdifferenzen von Flüssigkeiten und ihre Beziehung zum Saftsteigproblem der Bäume. Flora **93**: 127–154. 1904.

[32] POLLACCI, GINO, Intorno all' assimilazione chlorofillina. Memoria II. Atti Istituto Bot. Univ. Pavia II. **8**: 1–66. *pls. 3*. 1904.

[33] BARNES, C. R., On the food of green plants. BOT. GAZ. **18**: 405. 1893.

MATTEI discusses[34] the structure and ecology of a gall produced on *Quercus leptobalanus* Gussone, by *Cynips Mayri* Kieffel. The galls in question are of a brilliant carmine color and give off the odor of hyacinths. Their surfaces are covered with a viscid secretion, in which are usually to be found the more or less dissolved remains of small myriapods, arachnids, microlepidoptera, minute coleoptera and diptera, with a few other forms. Amid these animal remains are found two kinds of trichomes, one set composed of from three to six cells of unequal size, the largest at the distal extremity, all with reddish purple protoplasm, and resembling the secreting hairs of various carnivorous plants. The other set of trichomes consists of slender quadrifid hairs, radiating in the form of a cross and extending outward toward the portion of the viscid coating (the outer part) where there is the most animal matter. Professor Mattei suggests that the function of the stouter, reddish trichomes is to secrete a fluid which serves both to capture and to digest insects, and that the other trichomes are for absorption of the digested products. Whether the nutritive material obtained by the gall from captured insects, etc. is utilized for the growth of the gall in general, for the nourishment of the Cynips larva in particular, or even, in part, for the use of the oak host Professor Mattei leaves for future investigation and discussion. The subject of possible carnivorous habits in galls deserves to be fully investigated and promises to be full of interest.— JOSEPH Y. BERGEN.

BY THE USE of material infiltrated, imbedded, and cut in serial sections, Erwin Baur[35] has been enabled to trace the origin of the ascogenous hyphae in a number of lichen genera not heretofore studied accurately in this respect. From these researches it appears that the ascogenous hyphae have their origin in a well-developed carpogonium in the case of Parmelia, Anaptychia, Endocarpon, Gyrophora, Lecanora, and Cladonia. The carpogonium in these genera resembles that observed in the genus Collema, and Baur infers that it is sexual in its origin. Only in the genera Anaptychia and Endocarpon, however, was a fusion between the spermatia and the trichogyne observed, and even in these cases the result of the "sexual act" could not be further followed. In Solorina, as in Peltigera, Peltidea, and Nephromium, the origin of the carpogonium is stated to be probably apogamous, and this fact is correlated with the absence of spermogonia in these genera.

In view of the difficulty experienced by other observers in securing thorough infiltration of the lichen thallus, Baur's method may be summarized as follows: Damp material is fixed in a saturated solution of sublimate in 5% acetic acid. After thorough washing in water and alcoholic iodine, the

[34] MATTEI, G. E., Osservazioni biologiche intorno ad una galla. Bull. Orto Bot. Naples **1**:—(fasc. 4). *pl. 1*. 1903.

[35] BAUR, E., Untersuchungen über die Entwickelungsgeschichte der Flechtena pothecien, I. Bot Zeit. **62**[1]: 21–44. *pls. 1–2*. 1904.

specimens are brought gradually into absolute alcohol. They are then slowly infiltrated (8 days) with celloidin, and the blocks hardened in 70% alcohol (one day), and in a mixture of one part 70% alcohol and ten parts glycerin (at least two days). Sections are cut 20–25μ in thickness, stained with "Hämalaun" and mounted in balsam.—W. C. STURGIS.

DURING THE LAST four years contributions to our knowledge of gymnosperms have accumulated remarkably. In 1901 the reviewer had occasion to bring together the literature of the group in his preparation of the *Morphology of gymnosperms* (Morphology of spermatophytes, part I), but the record of that volume is very scanty in comparison with the material now available. This focusing of attention has not been along morphological lines alone, but has included the work of anatomists and paleobotonists as well. The initial part of a series of papers dealing with the comparative anatomy and phylogeny of the Coniferales by E. C. Jeffrey,[36] has just made its appearance, and promises to be of great service in connection with the phylogeny of a group whose relationships are very obscure. The genus Sequoia was chosen for the first memoir both because it is the sole survivor of a group once extensively displayed, and also because of its possible transition characters. One of the recognized peculiarities of the genus is the absence of resin ducts, but they have now been found in *S. gigantea* in all parts of the ovulate shoot, in the first annual ring of vigorous branches of adult trees, and in the leaf traces of very vigorous leaves of adult trees. In *S. sempervirens* resin ducts are entirely absent from these regions as well as all others; but in both species resin ducts appear in tangential rows in the wood of root and shoot as a result of injury to the tissues. The conclusion is reached that these resin ducts are an ancestral feature of Sequoia, and point strongly to the derivation of the genus from an abietineous stock, a stock which may have been ancestral to the living genera of the Abietineae as well. Morphologists have regarded the Abietineae as a relatively modern group of Coniferales, with Pinus as probably the most modern genus; but now the evidence of paleobotany and of anatomy is against this view, and morphologists are called upon to change their conceptions. The evidence is becoming increasingly clear that purely morphological systems of phylogeny are extremely uncertain.—J. M. C.

ITEMS OF TAXONOMIC INTEREST are as follows: M. L. FERNALD (Rhodora 6: 34–41. 1904), in presenting a list of New England Juncaceae, has established two new species and a variety, and has discussed *J. bufonius* and its representatives in America.—OAKES AMES (*idem* 27–31. *pl. 51*) has described a new Spiranthes of rather extensive range in the Atlantic region, often confused with *S. praecox* Watson of the southern states; and has also

[36] JEFFREY, EDWARD C., The comparative anatomy and phylogeny of the Coniferales. Parl I.—The genus Sequoia. Mem. Boston Soc. Nat. Hist. 5: 441–459. *pls. 68–71*. 1903.

(p. 44) substituted the name *S. Grayi* for *S. simplex* of Gray's *Manual* (5th ed.), the latter name being preoccupied by a West Indian species.—A. A. HELLER (Muhlenbergia **1**: 47–62. 1904) has published as new genera *Eburophyton* (*Cephalanthera oregana* Reich.) and *Polemoniella* (*Polemonium micranthum* Benth.), and new species of Sisyrinchium, Ranunculus, Erysimum (2). Rosa, Lathyrus, Trifolium, Gilia, Heliotropium, Orthocarpus, Valeriana, and Achillea.—E. L. GREENE (Ottawa Nat. **17**: 201–203. 1904) has described three new Canadian species of Antennaria.—R. CHODAT (Bull. Herb. Boiss. II. **4**: 285. 1904) has described a new genus (*Hassleropsis*) of Scrophulariaceae from Paraguay.—B. L. ROBINSON (Rhodora **6**: 50–53. 1904) has shown that two common species of Anychia have been confused, and that the *A. dichotoma* of Gray's *Manual* is *A. polygonoides* Raf., and that *A. capillacea* of the same book is *A. dichotoma* Mx.—In Ann. Mycologici for January (1904) the following new genera appear: *Oncopodium* Sacc. (Deuteromycetae), *Klastopsora* Dietel (Melampsoraceae), *Sirozythia* v. Höhnel (Nectrioideaceae), and *Conioscypha* v. Höhnel (Dematicae).—In the first part of his *Flora Manshuriae* (Acta. Hort. Petrop. **22**: 1–452. 1903), V. KOMAROV presents the Archichlamydeae through Saxifragaceae, describing only three new species (Aristolochia, Ranunculus, and Deutzia).—E. L. GREENE (Leaflets **1**: 33–48. 1904), in continuing his studies of "Polygonaceous genera," has described 26 new species of Polygonum.—FINET and GAGNEPAIN (Bull. Soc. Bot. France **50**: 517–557. *pls. 16–17*. 1904) have begun a series of contribution to the flora of eastern Asia, the first dealing mostly with a synopsis of Clematis (73 spp.) and the second (*idem* 601–627. *pl. 19*) presenting a synopsis of Thalictrum (51 spp.).—EM. BOUDIER (Bull. Soc. Mycol. France **20**: 19–22. *pl. 1*. 1904) has described a new genus (*Guilliermondia*) of Myriangiaceae, and PAUL VUILLEMIN (*idem* 26–33. *pl. 2*) a new genus (*Spinalia*) of Dispireae parasitic on Mucor.—OAKES AMES (Contrib. Ames Bot. Lab. 1) has published an account of the orchid flora of Southern Florida, including critical notes, a few novelties, and 12 plates.—E. D. MERRILL (Publ. 6. Bur. Gov't Labs. Depart. Interior, P. I.) has described some new or noteworthy Philippine plants, and has also discussed the American element in the Philippine flora.—N. L. BRITTON (Bull. Torr. Bot. Club **31**: 165–166. 1904) has described four new North American species of Betula.—WILLARD N. CLUTE (Fern Bull. **13**: 20–23. 1904) has described a new Equisetum from northern Illinois.—THEO. HOLM (Am. Jour. Sci. IV. **17**: 301–317. 1904), in his 21st "Studies in the Cyperaceae," has described 17 new species and 5 new varieties of Carex, and has discussed 10 noteworthy species.—ROBERT KELLER (Bot. Jahrb. **33**: 547–554. 1904) has described 12 new forms of Hypericum from eastern Asia.—SPENCER LE M. MOORE (Jour. Bot. **42**: 100–110. 1904), in describing Mons. A. Robert's Matto Grosso Plants, has described *Salpingacanthus* as a new genus of Acanthaceae (Ruellieae).—AGNES CHASE (Rhodora **6**: 65–71. *pls. 52–53*. 1904), in presenting the N. Am. allies of *Scirpus lacustris*, recognizes four species, one of which is new.—J. M. C.

NEWS.

PROFESSOR E. WARMING, of Copenhagen, has been elected a member of the Paris Academy of Sciences.

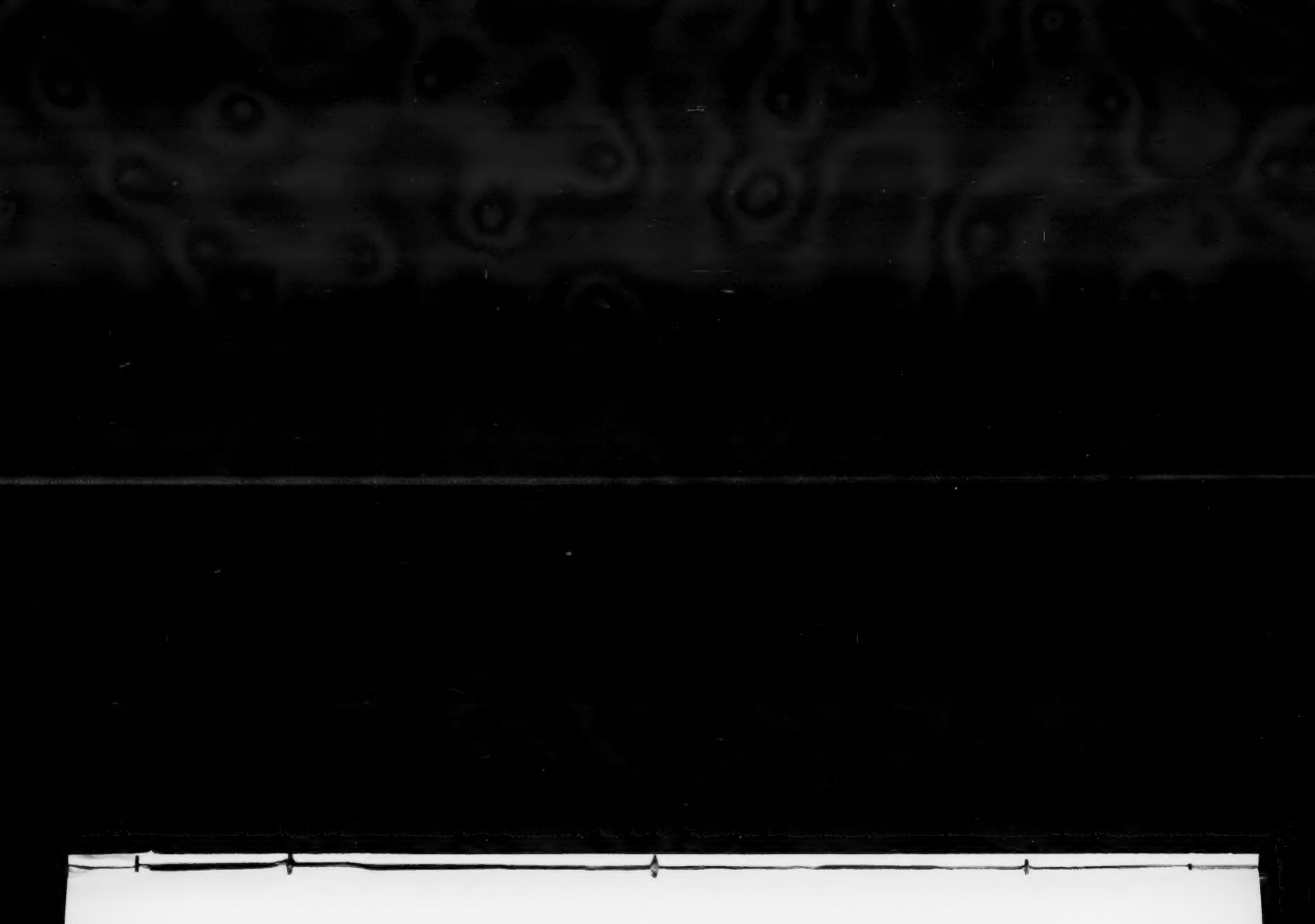
DR. CARL VON MARCHESETTI, director of the Museum of Natural History at Trieste, has been appointed director of the Botanical Gardens.

DR. B. E. LIVINGSTON, of the University of Chicago, has been awarded the Walker prize by the Boston Society of Natural History for a paper on *Ionic stimulation in plants.*

THE DEATH of Dr. August Garcke, professor of botany in Berlin and a curator of the Royal Botanical Museum, has been announced. He is best known as author of a *Flora of Germany.*

PROFESSOR F. S. EARLE, of the New York Botanical Garden, has been asked by the Cuban government to aid in the establishment of a Department of Agriculture. He has been granted leave of absence from the Garden for this purpose.

OHIO STATE UNIVERSITY has announced the work at its lake laboratory for the summer of 1904. The Cedar Point Lake Laboratory has an admirable location on Lake Erie near Sandusky, Ohio; it opens June 27 and closes August 5; and the courses in botany will be given by Professor W. A. Kellerman. The director is Professor Herbert Osborn, Ohio State University, Columbus.

THE DEATH of Dr. Karl Schumann, professor of botany in Berlin and a curator of the Royal Botanical Museum, has been announced. His numerous contributions to the morphology and taxonomy of flowering plants are well known, and especially his recent studies of the Cactaceae. A great collection of living representatives of this perplexing family was enabling Dr. Schumann to come to some very definite conclusions concerning their classification, and it is a great loss to taxonomy that these studies were not much further advanced.

DR. JOSÉ RAMIREZ, for many years head of the section of botany of the Instituto Medico Nacional of the City of Mexico, died recently. He has for many years been one of the leading scientific men of Mexico and perhaps has done more than any other person to develop botanical research in that country. He has also occupied for a long time the position of secretary to the Board of Health of Mexico, where he has accomplished much in bettering the sanitary conditions in that country. He is the author of some thirty-seven papers on botanical subjects, a list of which is published as a supplement to his *Sinonimia vulgar y cientifica de las plantas* published in 1902.—J. N. ROSE.